

WHAT IS CLAIMED IS:

1. A method of treating a hydrocarbon containing formation in situ, comprising:
5 providing heat from one or more heat sources to at least one portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation;
controlling the heat from the one or more heat sources such that an average temperature within at least a majority of the selected section of the formation is less than 10 about 375 °C; and
producing a mixture from the formation.

2. The method of claim 1, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

3. The method of claim 1, wherein controlling formation conditions comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

4. The method of claim 1, wherein the one or more heat sources comprise electrical heaters.

5. The method of claim 1, wherein the one or more heat sources comprise surface burners.

6. The method of claim 1, wherein the one or more heat sources comprise flameless distributed combustors.

30 7. The method of claim 1, wherein the one or more heat sources comprise natural distributed combustors.

8. The method of claim 1, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

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9. The method of claim 1, further comprising controlling a pressure within at least a majority of the selected section of the formation with a valve coupled to at least one of the one or more heat sources.

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10. The method of claim 1, further comprising controlling a pressure within at least a majority of the selected section of the formation with a valve coupled to a production well located in the formation.

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11. The method of claim 1, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

12. The method of claim 1, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

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heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity(C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

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wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

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13. The method of claim 1, wherein allowing the heat to transfer from the one or more heat sources to the selected section comprises transferring heat substantially by conduction.

5 14. The method of claim 1, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

10 15. The method of claim 1, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

15 16. The method of claim 1, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

20 17. The method of claim 1, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

25 18. The method of claim 1, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

30 19. The method of claim 1, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

20. The method of claim 1, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

21. The method of claim 1, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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22. The method of claim 1, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

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23. The method of claim 1, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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24. The method of claim 1, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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25. The method of claim 1, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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26. The method of claim 1, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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27. The method of claim 1, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, and wherein the hydrogen is greater than about 10 % by volume of the non-condensable component and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

28. The method of claim 1, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5 29. The method of claim 1, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

10 30. The method of claim 1, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

15 31. The method of claim 1, further comprising controlling formation conditions such that the produced mixture comprises a partial pressure of H₂ within the mixture greater than about 0.5 bar.

15 32. The method of claim 31, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

20 33. The method of claim 1, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

20 34. The method of claim 1, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

25 35. The method of claim 1, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

36. The method of claim 1, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

5 37. The method of claim 1, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

38. The method of claim 1, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

10 39. The method of claim 1, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

15 40. The method of claim 1, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 41. The method of claim 1, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 42. The method of claim 1, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30 43. The method of claim 1, further comprising separating the produced mixture into a gas stream and a liquid stream.

44. The method of claim 1, further comprising separating the produced mixture into a gas stream and a liquid stream and separating the liquid stream into an aqueous stream and a non-aqueous stream.

5 45. The method of claim 1, wherein the produced mixture comprises H₂S, the method further comprising separating a portion of the H₂S from non-condensable hydrocarbons.

46. The method of claim 1, wherein the produced mixture comprises CO₂, the method further comprising separating a portion of the CO₂ from non-condensable hydrocarbons.

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47. The method of claim 1, wherein the mixture is produced from a production well, wherein the heating is controlled such that the mixture can be produced from the formation as a vapor.

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48. The method of claim 1, wherein the mixture is produced from a production well, the method further comprising heating a wellbore of the production well to inhibit condensation of the mixture within the wellbore.

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49. The method of claim 1, wherein the mixture is produced from a production well, wherein a wellbore of the production well comprises a heater element configured to heat the formation adjacent to the wellbore, and further comprising heating the formation with the heater element to produce the mixture, wherein the mixture comprises a large non-condensable hydrocarbon gas component and H₂.

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50. The method of claim 1, wherein the minimum pyrolysis temperature is about 270 °C.

51. The method of claim 1, further comprising maintaining the pressure within the formation above about 2.0 bar absolute to inhibit production of fluids having carbon numbers above 25.

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52. The method of claim 1, further comprising controlling pressure within the formation in a range from about atmospheric pressure to about 100 bar, as measured at a wellhead of a production well, to control an amount of condensable hydrocarbons within the produced mixture, wherein the pressure is reduced to increase production of condensable hydrocarbons, and wherein the pressure is increased to increase production of non-condensable hydrocarbons.

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53. The method of claim 1, further comprising controlling pressure within the formation in a range from about atmospheric pressure to about 100 bar, as measured at a wellhead of a production well, to control an API gravity of condensable hydrocarbons within the produced mixture, wherein the pressure is reduced to decrease the API gravity, and wherein the pressure is increased to reduce the API gravity.

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54. A method of treating a hydrocarbon containing formation in situ, comprising:

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providing heat from one or more heat sources to at least a portion of the formation;

allowing the heat to transfer from at least the portion to a selected section of the formation substantially by conduction of heat;

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pyrolyzing at least some hydrocarbons within the selected section of the formation; and

producing a mixture from the formation.

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55. The method of claim 54, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

56. The method of claim 54, wherein the one or more heat sources comprise electrical heaters.

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57. The method of claim 54, wherein the one or more heat sources comprise surface burners.

58. The method of claim 54, wherein the one or more heat sources comprise flameless distributed combustors.

5 59. The method of claim 54, wherein the one or more heat sources comprise natural distributed combustors.

10 60. The method of claim 54, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

15 61. The method of claim 54, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1.0 °C per day during pyrolysis.

62. The method of claim 54, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

20 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

25 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

30 63. The method of claim 54, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

64. The method of claim 54, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5 65. The method of claim 54, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

10 66. The method of claim 54, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

15 67. The method of claim 54, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

20 68. The method of claim 54, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

69. The method of claim 54, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

25 70. The method of claim 54, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

71. The method of claim 54, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

5 72. The method of claim 54, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

10 73. The method of claim 54, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

15 74. The method of claim 54, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

20 75. The method of claim 54, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

25 76. The method of claim 54, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

77. The method of claim 54, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

30 78. The method of claim 54, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

79. The method of claim 54, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

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80. The method of claim 79, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

10 81. The method of claim 54, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

15 82. The method of claim 54, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

15 83. The method of claim 54, further comprising:

providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

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84. The method of claim 54, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

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85. The method of claim 54, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

86. The method of claim 54, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

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87. The method of claim 54, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

5 88. The method of claim 54, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

10 89. The method of claim 54, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

15 90. The method of claim 54, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

20 91. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation; and
heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

25 92. The method of claim 91, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

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93. The method of claim 91, wherein controlling formation conditions comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

5 94. The method of claim 91, wherein the one or more heat sources comprise electrical heaters.

10 95. The method of claim 91, wherein the one or more heat sources comprise surface burners.

15 96. The method of claim 91, wherein the one or more heat sources comprise flameless distributed combustors.

20 97. The method of claim 91, wherein the one or more heat sources comprise natural distributed combustors.

98. The method of claim 91, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

25 99. The method of claim 91, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

100. The method of claim 91, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than P_{wr} , wherein P_{wr} is calculated by the equation:

$$P_{wr} = h * V * C_v * \rho_B$$

5 wherein P_{wr} is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

101. The method of claim 91, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

10 102. The method of claim 91, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

15 103. The method of claim 91, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

20 104. The method of claim 91, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

25 105. The method of claim 91, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

106. The method of claim 91, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

107. The method of claim 91, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5 108. The method of claim 91, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

10 109. The method of claim 91, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

15 110. The method of claim 91, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

20 111. The method of claim 91, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

25 112. The method of claim 91, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 113. The method of claim 91, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

114. The method of claim 91, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5 115. The method of claim 91, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

10 116. The method of claim 91, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

15 117. The method of claim 91, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

20 118. The method of claim 117, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

25 119. The method of claim 91, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

120. The method of claim 91, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

25 121. The method of claim 91, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

122. The method of claim 91, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

5 123. The method of claim 91, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

10 124. The method of claim 91, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

15 125. The method of claim 91, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

126. The method of claim 91, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 127. The method of claim 91, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 128. The method of claim 91, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30 129. A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heat sources to at least a portion of the formation;

allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

5 controlling the heat from the one or more heat sources such that an average temperature within at least a majority of the selected section of the formation is less than about 370 °C such that production of a substantial amount of hydrocarbons having carbon numbers greater than 25 is inhibited;

10 controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least 2.0 bar; and

producing a mixture from the formation, wherein about 0.1 % by weight of the produced mixture to about 15 % by weight of the produced mixture are olefins, and wherein an average carbon number of the produced mixture ranges from 1-25.

15 130. The method of claim 129, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

20 131. The method of claim 129, wherein controlling formation conditions comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

132. The method of claim 129, wherein the one or more heat sources comprise electrical heaters.

25 133. The method of claim 129, wherein the one or more heat sources comprise surface burners.

134. The method of claim 129, wherein the one or more heat sources comprise flameless distributed combustors.

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135. The method of claim 129, wherein the one or more heat sources comprise natural distributed combustors.

136. The method of claim 129, further comprising controlling a pressure and a 5 temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

10 137. The method of claim 129, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

15 138. The method of claim 129, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

20 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

25 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

139. The method of claim 129, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

30 140. The method of claim 129, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

141. The method of claim 129, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

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142. The method of claim 129, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

10 143. The method of claim 129, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

15 144. The method of claim 129, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

20 145. The method of claim 129, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

25 146. The method of claim 129, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

147. The method of claim 129, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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148. The method of claim 129, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

5 149. The method of claim 129, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

10 150. The method of claim 129, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

15 151. The method of claim 129, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

20 152. The method of claim 129, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

153. The method of claim 129, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

25 154. The method of claim 129, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 155. The method of claim 154, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

156. The method of claim 129, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5 157. The method of claim 129, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

10 158. The method of claim 129, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

15 159. The method of claim 129, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

20 160. The method of claim 129, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

161. The method of claim 129, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

25 162. The method of claim 129, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

30 163. The method of claim 129, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat

sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

164. The method of claim 129, further comprising providing heat from three or more
5 heat sources to at least a portion of the formation, wherein three or more of the heat
sources are located in the formation in a unit of heat sources, wherein the unit of heat
sources comprises a triangular pattern, and wherein a plurality of the units are repeated
over an area of the formation to form a repetitive pattern of units.

10 165. The method of claim 129, further comprising separating the produced mixture
into a gas stream and a liquid stream.

15 166. The method of claim 129, further comprising separating the produced mixture
into a gas stream and a liquid stream and separating the liquid stream into an aqueous
stream and a non-aqueous stream.

20 167. The method of claim 129, wherein the produced mixture comprises H₂S, the
method further comprising separating a portion of the H₂S from non-condensable
hydrocarbons.

25 168. The method of claim 129, wherein the produced mixture comprises CO₂, the
method further comprising separating a portion of the CO₂ from non-condensable
hydrocarbons.

169. The method of claim 129, wherein the mixture is produced from a production
well, wherein the heating is controlled such that the mixture can be produced from the
formation as a vapor.

30 170. The method of claim 129, wherein the mixture is produced from a production
well, the method further comprising heating a wellbore of the production well to inhibit
condensation of the mixture within the wellbore.

171. The method of claim 129, wherein the mixture is produced from a production well, wherein a wellbore of the production well comprises a heater element configured to heat the formation adjacent to the wellbore, and further comprising heating the formation with the heater element to produce the mixture, wherein the produced mixture comprise a large non-condensable hydrocarbon gas component and H₂.

172. The method of claim 129, wherein the minimum pyrolysis temperature is about 270 °C.

173. The method of claim 129, further comprising maintaining the pressure within the formation above about 2.0 bar absolute to inhibit production of fluids having carbon numbers above 25.

174. The method of claim 129, further comprising controlling pressure within the formation in a range from about atmospheric pressure to about 100 bar absolute, as measured at a wellhead of a production well, to control an amount of condensable fluids within the produced mixture, wherein the pressure is reduced to increase production of condensable fluids, and wherein the pressure is increased to increase production of non-condensable fluids.

175. The method of claim 129, further comprising controlling pressure within the formation in a range from about atmospheric pressure to about 100 bar absolute, as measured at a wellhead of a production well, to control an API gravity of condensable fluids within the produced mixture, wherein the pressure is reduced to decrease the API gravity, and wherein the pressure is increased to reduce the API gravity.

176. A method of treating a hydrocarbon containing formation in situ, comprising: providing heat from one or more heat sources to at least a portion of the formation;

allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute; and

5 producing a mixture from the formation.

177. The method of claim 176, wherein controlling the pressure comprises controlling the pressure with a valve coupled to at least one of the one or more heat sources.

10 178. The method of claim 176, wherein controlling the pressure comprises controlling the pressure with a valve coupled to a production well located in the formation.

15 179. The method of claim 176, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

20 180. The method of claim 176, wherein controlling formation conditions comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

25 181. The method of claim 176, wherein the one or more heat sources comprise electrical heaters.

182. The method of claim 176, wherein the one or more heat sources comprise surface burners.

30 183. The method of claim 176, wherein the one or more heat sources comprise flameless distributed combustors.

184. The method of claim 176, wherein the one or more heat sources comprise natural distributed combustors.

185. The method of claim 176, further comprising controlling a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

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186. The method of claim 176, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

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187. The method of claim 176, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

15 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

20 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

25 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

188. The method of claim 176, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

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189. The method of claim 176, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

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190. The method of claim 176, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

191. The method of claim 176, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

192. The method of claim 176, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

193. The method of claim 176, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

194. The method of claim 176, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

195. The method of claim 176, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

196. The method of claim 176, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

197. The method of claim 176, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

198. The method of claim 176, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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199. The method of claim 176, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

10 200. The method of claim 176, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

15 201. The method of claim 176, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

20 202. The method of claim 176, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

25 203. The method of claim 176, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

204. The method of claim 176, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 205. The method of claim 204, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

206. The method of claim 176, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5

207. The method of claim 176, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

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208. The method of claim 176, further comprising:

providing hydrogen (H_2) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

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209. The method of claim 176, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

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210. The method of claim 176, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

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211. The method of claim 176, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

212. The method of claim 176, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

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213. The method of claim 176, wherein producing the mixture from the formation comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

214. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the
formation;

5 allowing the heat to transfer from the one or more heat sources to a selected
section of the formation; and

controlling a pressure within at least a majority of the selected section of the
formation, wherein the controlled pressure is at least about 2.0 bar absolute;

10 controlling the heat from the one or more heat sources such that an average
temperature within at least a majority of the selected section of the formation is less than
about 375 °C; and

producing a mixture from the formation.

15 215. The method of claim 214, wherein the one or more heat sources comprise at least
two heat sources, and wherein superposition of heat from at least the two heat sources
pyrolyzes at least some hydrocarbons within the selected section of the formation.

20 216. The method of claim 214, wherein controlling formation conditions comprises
maintaining a temperature within the selected section within a pyrolysis temperature
range.

217. The method of claim 214, wherein the one or more heat sources comprise
electrical heaters.

25 218. The method of claim 214, wherein the one or more heat sources comprise surface
burners.

219. The method of claim 214, wherein the one or more heat sources comprise
flameless distributed combustors.

220. The method of claim 214, wherein the one or more heat sources comprise natural distributed combustors.

221. The method of claim 214, further comprising controlling a pressure and a 5 temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

222. The method of claim 214, further comprising controlling the heat such that an 10 average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

223. The method of claim 214, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

15 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

20 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

25 224. The method of claim 214, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

30 225. The method of claim 214, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

226. The method of claim 214, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5 227. The method of claim 214, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

10 228. The method of claim 214, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

15 229. The method of claim 214, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

20 230. The method of claim 214, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

231. The method of claim 214, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

25 232. The method of claim 214, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

30 233. The method of claim 214, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable

hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

234. The method of claim 214, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

235. The method of claim 214, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

236. The method of claim 214, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

237. The method of claim 214, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

238. The method of claim 214, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

239. The method of claim 214, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

240. The method of claim 214, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

241. The method of claim 214, wherein controlling the heat further comprises controlling the heat such that coke production is inhibited.

5 242. The method of claim 214, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

10 243. The method of claim 242, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

15 244. The method of claim 214, further comprising altering the pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

20 245. The method of claim 214, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

246. The method of claim 214, further comprising:
20 providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

25 247. The method of claim 214, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

248. The method of claim 214, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

249. The method of claim 214, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

250. The method of claim 214, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

251. The method of claim 214, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

252. The method of claim 214, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

253. The method of claim 214, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

254. A method of treating a hydrocarbon containing formation in situ, comprising:
25 providing heat from one or more heat sources to at least a portion of the formation;

allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

producing a mixture from the formation, wherein at least a portion of the mixture is produced during the pyrolysis and the mixture moves through the formation in a vapor phase; and

maintaining a pressure within at least a majority of the selected section above about 2.0 bar absolute.

255. The method of claim 254, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

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256. The method of claim 254, wherein controlling formation conditions comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

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257. The method of claim 254, wherein the one or more heat sources comprise electrical heaters.

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258. The method of claim 254, wherein the one or more heat sources comprise surface burners.

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259. The method of claim 254, wherein the one or more heat sources comprise flameless distributed combustors.

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260. The method of claim 254, wherein the one or more heat sources comprise natural distributed combustors.

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261. The method of claim 254, further comprising controlling the pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

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262. The method of claim 254, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

263. The method of claim 254, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

264. The method of claim 254, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

265. The method of claim 254, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

266. The method of claim 254, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

267. The method of claim 254, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

268. The method of claim 254, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

269. The method of claim 254, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5 270. The method of claim 254, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

10 271. The method of claim 254, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

15 272. The method of claim 254, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

20 273. The method of claim 254, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

25 274. The method of claim 254, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

275. The method of claim 254, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

276. The method of claim 254, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5 277. The method of claim 254, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

10 278. The method of claim 254, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

15 279. The method of claim 254, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

20 280. The method of claim 254, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

281. The method of claim 254, wherein the pressure is measured at a wellhead of a production well.

25 282. The method of claim 254, wherein the pressure is measured at a location within a wellbore of the production well.

283. The method of claim 254, wherein the pressure is maintained below about 100 bar absolute.

284. The method of claim 254, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

5 285. The method of claim 284, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

10 286. The method of claim 254, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

15 287. The method of claim 254, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

20 288. The method of claim 254, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

25 289. The method of claim 254, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

290. The method of claim 254, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

30 291. The method of claim 254, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

292. The method of claim 254, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

5 293. The method of claim 254, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

10 294. The method of claim 254, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

15 295. The method of claim 254, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

20 296. A method of treating a hydrocarbon containing formation in situ, comprising:
 providing heat from one or more heat sources to at least a portion of the formation;
 allowing the heat to transfer from the one or more heat sources to a selected section of the formation;
25 maintaining a pressure within at least a majority of the selected section of the formation above 2.0 bar absolute; and
 producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity higher than an API gravity of condensable hydrocarbons in a mixture producible from the formation at the same temperature and at atmospheric pressure.

297. The method of claim 296, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

5 298. The method of claim 296, wherein controlling formation conditions comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

10 299. The method of claim 296, wherein the one or more heat sources comprise electrical heaters.

15 300. The method of claim 296, wherein the one or more heat sources comprise surface burners.

20 301. The method of claim 296, wherein the one or more heat sources comprise flameless distributed combustors.

302. The method of claim 296, wherein the one or more heat sources comprise natural distributed combustors.

25 303. The method of claim 296, further comprising controlling the pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

304. The method of claim 296, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

30 305. The method of claim 296, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

5 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h*V*C_v*\rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 10 °C/day.

306. The method of claim 296, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

15 307. The method of claim 296, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

20 308. The method of claim 296, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

309. The method of claim 296, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

25 310. The method of claim 296, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

311. The method of claim 296, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5 312. The method of claim 296, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

10 313. The method of claim 296, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

15 314. The method of claim 296, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

20 315. The method of claim 296, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

25 316. The method of claim 296, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

317. The method of claim 296, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

318. The method of claim 296, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5 319. The method of claim 296, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

10 320. The method of claim 296, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

15 321. The method of claim 296, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

20 322. The method of claim 296, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

25 323. The method of claim 296, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

324. The method of claim 296, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

30 325. The method of claim 296, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

326. The method of claim 296, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

327. The method of claim 296, further comprising:

5 providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

10 328. The method of claim 296, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

15 329. The method of claim 296, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

330. The method of claim 296, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

20 331. The method of claim 296, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

25 332. The method of claim 296, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

333. The method of claim 296, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

334. The method of claim 296, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

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335. A method of treating a hydrocarbon containing formation in situ, comprising:
10 providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation;
15 maintaining a pressure within at least a majority of the selected section of the formation to above 2.0 bar absolute; and
producing a fluid from the formation, wherein condensable hydrocarbons within the fluid comprise an atomic hydrogen to atomic carbon ratio of greater than about 1.75.

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336. The method of claim 335, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

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337. The method of claim 335, wherein controlling formation conditions comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

338. The method of claim 335, wherein the one or more heat sources comprise electrical heaters.

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339. The method of claim 335, wherein the one or more heat sources comprise surface burners.

340. The method of claim 335, wherein the one or more heat sources comprise flameless distributed combustors.

341. The method of claim 335, wherein the one or more heat sources comprise natural distributed combustors.

342. The method of claim 335, further comprising controlling the pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

343. The method of claim 335, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

344. The method of claim 335, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:
heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and
wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:
$$Pwr = h * V * C_v * \rho_B$$
wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

345. The method of claim 335, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

346. The method of claim 335, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

5 347. The method of claim 335, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

10 348. The method of claim 335, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

15 349. The method of claim 335, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

20 350. The method of claim 335, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

25 351. The method of claim 335, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

30 352. The method of claim 335, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

353. The method of claim 335, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

354. The method of claim 335, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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355. The method of claim 335, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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356. The method of claim 335, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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357. The method of claim 335, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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358. The method of claim 335, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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359. The method of claim 335, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

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360. The method of claim 335, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

361. The method of claim 335, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

5 362. The method of claim 335, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

363. The method of claim 335, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

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364. The method of claim 335, further comprising altering the pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

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365. The method of claim 335, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

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366. The method of claim 335, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

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367. The method of claim 335, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

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368. The method of claim 335, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

369. The method of claim 335, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

370. The method of claim 335, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

371. The method of claim 335, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

372. The method of claim 335, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

373. The method of claim 335, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

374. A method of treating a hydrocarbon containing formation in situ, comprising:
25 providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation;
maintaining a pressure within at least a majority of the selected section of the formation to above 2.0 bar absolute; and
30 producing a mixture from the formation, wherein the produced mixture comprises a higher amount of non-condensable components as compared to non-condensable

components producible from the formation under the same temperature conditions and at atmospheric pressure.

375. The method of claim 374, wherein the one or more heat sources comprise at least 5 two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

10 376. The method of claim 374, wherein controlling formation conditions comprises

maintaining a temperature within the selected section within a pyrolysis temperature range.

15 377. The method of claim 374, wherein the one or more heat sources comprise electrical heaters.

378. The method of claim 374, wherein the one or more heat sources comprise surface 20 burners.

379. The method of claim 374, wherein the one or more heat sources comprise flameless distributed combustors.

25 380. The method of claim 374, wherein the one or more heat sources comprise natural distributed combustors.

381. The method of claim 374, further comprising controlling the pressure and a 30 temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

382. The method of claim 374, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during 35 pyrolysis.

383. The method of claim 374, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

5 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

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$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

15 384. The method of claim 374, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

20 385. The method of claim 374, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

386. The method of claim 374, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

25 387. The method of claim 374, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

30 388. The method of claim 374, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

389. The method of claim 374, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

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390. The method of claim 374, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

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391. The method of claim 374, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

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392. The method of claim 374, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

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393. The method of claim 374, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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394. The method of claim 374, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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395. The method of claim 374, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

396. The method of claim 374, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5 397. The method of claim 374, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

10 398. The method of claim 374, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

15 399. The method of claim 374, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

20 400. The method of claim 374, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

25 401. The method of claim 374, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 402. The method of claim 374, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

403. The method of claim 374, further comprising altering the pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

404. The method of claim 374, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons
within the section; and
heating a portion of the section with heat from hydrogenation.

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405. The method of claim 374, wherein the produced mixture comprises hydrogen and
condensable hydrocarbons, the method further comprising hydrogenating a portion of the
produced condensable hydrocarbons with at least a portion of the produced hydrogen.

10 406. The method of claim 374, wherein allowing the heat to transfer comprises
increasing a permeability of a majority of the selected section to greater than about 100
millidarcy.

15 407. The method of claim 374, wherein allowing the heat to transfer comprises
substantially uniformly increasing a permeability of a majority of the selected section.

20 408. The method of claim 374, further comprising controlling the heat to yield greater
than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer
Assay.

409. The method of claim 374, wherein producing the mixture comprises producing
the mixture in a production well, and wherein at least about 7 heat sources are disposed in
the formation for each production well.

25 410. The method of claim 374, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat
sources are located in the formation in a unit of heat sources, and wherein the unit of heat
sources comprises a triangular pattern.

30 411. The method of claim 374, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat

sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

5 412. A method of treating a hydrocarbon containing formation in situ, comprising:
 providing heat from one or more heat sources to at least a portion of the
 formation;
 allowing the heat to transfer from the one or more heat sources to a selected
 section of the formation such that superimposed heat from the one or more heat sources
10 pyrolyzes at least about 20 % by weight of hydrocarbons within the selected section of
 the formation; and
 producing a mixture from the formation.

15 413. The method of claim 412, wherein the one or more heat sources comprise at least
 two heat sources, and wherein superposition of heat from at least the two heat sources
 pyrolyzes at least some hydrocarbons within the selected section of the formation.

20 414. The method of claim 412, wherein controlling formation conditions comprises
 maintaining a temperature within the selected section within a pyrolysis temperature
 range.

25 415. The method of claim 412, wherein the one or more heat sources comprise
 electrical heaters.

30 416. The method of claim 412, wherein the one or more heat sources comprise surface
 burners.

 417. The method of claim 412, wherein the one or more heat sources comprise
 flameless distributed combustors.

418. The method of claim 412, wherein the one or more heat sources comprise natural distributed combustors.

419. The method of claim 412, further comprising controlling a pressure and a 5 temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

420. The method of claim 412, further comprising controlling the heat such that an 10 average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

421. The method of claim 412, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

15 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

20 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

25 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

422. The method of claim 412, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

423. The method of claim 412, wherein providing heat from the one or more heat 30 sources comprises heating the selected formation such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

424. The method of claim 412, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5 425. The method of claim 412, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

10 426. The method of claim 412, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

15 427. The method of claim 412, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

20 428. The method of claim 412, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

25 429. The method of claim 412, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

430. The method of claim 412, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

30 431. The method of claim 412, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable

hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

432. The method of claim 412, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

433. The method of claim 412, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

434. The method of claim 412, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

435. The method of claim 412, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

436. The method of claim 412, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

437. The method of claim 412, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

438. The method of claim 412, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

439. The method of claim 412, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

5 440. The method of claim 412, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

10 441. The method of claim 412, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

15 442. The method of claim 412, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

443. The method of claim 412, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

20 444. The method of claim 412, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

25 445. The method of claim 412, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

30 446. The method of claim 412, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

447. The method of claim 412, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

448. The method of claim 412, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

449. The method of claim 412, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

450. The method of claim 412, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

451. The method of claim 412, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

452. A method of treating a hydrocarbon containing formation in situ, comprising: providing heat from one or more heat sources to at least a portion of the formation;

allowing the heat to transfer from the one or more heat sources to a selected section of the formation such that superimposed heat from the one or more heat sources pyrolyzes at least about 20 % of hydrocarbons within the selected section of the formation; and

producing a mixture from the formation, wherein the mixture comprises a condensable component having an API gravity of at least about 25°.

453. The method of claim 452, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

5 454. The method of claim 452, wherein controlling formation conditions comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

10 455. The method of claim 452, wherein the one or more heat sources comprise electrical heaters.

15 456. The method of claim 452, wherein the one or more heat sources comprise surface burners.

20 457. The method of claim 452, wherein the one or more heat sources comprise flameless distributed combustors.

25 458. The method of claim 452, wherein the one or more heat sources comprise natural distributed combustors.

459. The method of claim 452, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

30 460. The method of claim 452, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

461. The method of claim 452, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

5 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 10 °C/day.

462. The method of claim 452, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

15 463. The method of claim 452, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

20 464. The method of claim 452, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

25 465. The method of claim 452, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

466. The method of claim 452, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

467. The method of claim 452, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

5 468. The method of claim 452, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

10 469. The method of claim 452, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

15 470. The method of claim 452, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

20 471. The method of claim 452, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

25 472. The method of claim 452, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

473. The method of claim 452, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

474. The method of claim 452, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5 475. The method of claim 452, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

10 476. The method of claim 452, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

15 477. The method of claim 452, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

20 478. The method of claim 452, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

25 479. The method of claim 452, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 480. The method of claim 452, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

481. The method of claim 452, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

482. The method of claim 452, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

483. The method of claim 452, further comprising:

5 providing hydrogen (H_2) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

484. The method of claim 452, wherein the produced mixture comprises hydrogen and 10 condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

485. The method of claim 452, wherein allowing the heat to transfer comprises 15 increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

486. The method of claim 452, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

20 487. The method of claim 452, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

25 488. The method of claim 452, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

489. The method of claim 452, further comprising providing heat from three or more 30 heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

490. The method of claim 452, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

491. A method of treating a layer of a hydrocarbon containing formation in situ, comprising:

10 providing heat from one or more heat sources to at least a portion of the layer, wherein the one or more heat sources are positioned proximate an edge of the layer;

15 allowing the heat to transfer from the one or more heat sources to a selected section of the layer such that superimposed heat from the one or more heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation; and

15 producing a mixture from the formation.

492. The method of claim 491, wherein the one or more heat sources are laterally spaced from a center of the layer.

20 493. The method of claim 491, wherein the one or more heat sources are positioned in a staggered line.

25 494. The method of claim 491, wherein the one or more heat sources positioned proximate the edge of the layer can increase an amount of hydrocarbons produced per unit of energy input to the one or more heat sources.

495. The method of claim 491, wherein the one or more heat sources positioned proximate the edge of the layer can increase the volume of formation undergoing pyrolysis per unit of energy input to the one or more heat sources.

496. The method of claim 491, wherein the one or more heat sources comprise electrical heaters.

497. The method of claim 491, wherein the one or more heat sources comprise surface burners.

498. The method of claim 491, wherein the one or more heat sources comprise flameless distributed combustors.

499. The method of claim 491, wherein the one or more heat sources comprise natural distributed combustors.

500. The method of claim 491, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

501. The method of claim 491, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1.0 °C per day during pyrolysis.

502. The method of claim 491, wherein providing heat from the one or more heat sources to at least the portion of the layer comprises:
heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and
wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein P_{wr} is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

5 503. The method of claim 491, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

10 504. The method of claim 491, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

15 505. The method of claim 491, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

506. The method of claim 491, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

20 507. The method of claim 491, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

25 508. The method of claim 491, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

30 509. The method of claim 491, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

510. The method of claim 491, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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511. The method of claim 491, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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512. The method of claim 491, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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513. The method of claim 491, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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514. The method of claim 491, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

25

515. The method of claim 491, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

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516. The method of claim 491, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

517. The method of claim 491, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

5 518. The method of claim 491, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

10 519. The method of claim 491, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

15 520. The method of claim 519, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

20 521. The method of claim 491, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

25 522. The method of claim 491, further comprising controlling formation conditions, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

30 523. The method of claim 491, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

524. The method of claim 491, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

525. The method of claim 491, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

5 526. The method of claim 491, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

10 527. The method of claim 491, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

15 528. The method of claim 491, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 529. The method of claim 491, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 530. The method of claim 491, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30 531. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation; and

controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure; and
producing a mixture from the formation.

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532. The method of claim 531, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

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533. The method of claim 531, wherein controlling formation conditions comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

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534. The method of claim 531, wherein the one or more heat sources comprise electrical heaters.

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535. The method of claim 531, wherein the one or more heat sources comprise surface burners.

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536. The method of claim 531, wherein the one or more heat sources comprise flameless distributed combustors.

537. The method of claim 531, wherein the one or more heat sources comprise natural distributed combustors.

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538. The method of claim 531, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

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539. The method of claim 531, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

5 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10
10 $^{\circ}\text{C}/\text{day}$.

540. The method of claim 531, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

15 541. The method of claim 531, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 $\text{W}/(\text{m } ^{\circ}\text{C})$.

20 542. The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25 $^{\circ}$.

543. The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

25 544. The method of claim 531, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

545. The method of claim 531, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5 546. The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

10 547. The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

15 548. The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

20 549. The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

25 550. The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

551. The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

552. The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5 553. The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

10 554. The method of claim 531, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

15 555. The method of claim 531, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

20 556. The method of claim 531, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

25 557. The method of claim 531, wherein the controlled pressure is at least about 2.0 bar absolute.

558. The method of claim 531, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 559. The method of claim 531, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

560. The method of claim 531, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5 561. The method of claim 531, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

10 562. The method of claim 531, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

15 563. The method of claim 531, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

20 564. The method of claim 531, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

25 565. The method of claim 531, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

566. The method of claim 531, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

30 567. The method of claim 531, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

568. The method of claim 531, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

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569. The method of claim 531, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

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570. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;

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allowing the heat to transfer from the one or more heat sources to a selected section of the formation to raise an average temperature within the selected section to, or above, a temperature that will pyrolyze hydrocarbons within the selected section;

producing a mixture from the formation; and

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controlling API gravity of the produced mixture to be greater than about 25 degrees API by controlling average pressure and average temperature in the selected section such that the average pressure in the selected section is greater than the pressure (p) set forth in the following equation for an assessed average temperature (T) in the selected section:

$$p = e^{[-44000/T + 67]}$$

25

where p is measured in psia and T is measured in ° Kelvin.

571. The method of claim 570, wherein the API gravity of the produced mixture is controlled to be greater than about 30 degrees API, and wherein the equation is:

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$$p = e^{[-31000/T + 51]}$$

572. The method of claim 570, wherein the API gravity of the produced mixture is controlled to be greater than about 35 degrees API, and wherein the equation is:

$$p = e^{[-22000/T + 38]}$$

5 573. The method of claim 570, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

10 574. The method of claim 570, wherein controlling the average temperature comprises maintaining a temperature in the selected section within a pyrolysis temperature range.

15 575. The method of claim 570, wherein the one or more heat sources comprise electrical heaters.

576. The method of claim 570, wherein the one or more heat sources comprise surface burners.

20 577. The method of claim 570, wherein the one or more heat sources comprise flameless distributed combustors.

578. The method of claim 570, wherein the one or more heat sources comprise natural distributed combustors.

25 579. The method of claim 570, further comprising controlling a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

30 580. The method of claim 570, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

581. The method of claim 570, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

5 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

10 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

15 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

15 582. The method of claim 570, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

20 583. The method of claim 570, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

25 584. The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

585. The method of claim 570, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

586. The method of claim 570, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5 587. The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

10 588. The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

15 589. The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

20 590. The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

25 591. The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

592. The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

593. The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5 594. The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

10 595. The method of claim 570, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

15 596. The method of claim 570, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

20 597. The method of claim 570, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

25 598. The method of claim 570, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

599. The method of claim 570, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

30 600. The method of claim 570, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

601. The method of claim 570, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

602. The method of claim 570, further comprising:

5 providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

10 603. The method of claim 570, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

15 604. The method of claim 570, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

605. The method of claim 570, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

20 606. The method of claim 570, wherein the heat is controlled to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

25 607. The method of claim 570, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

30 608. The method of claim 570, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

609. The method of claim 570, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

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610. A method of treating a hydrocarbon containing formation in situ, comprising:
10 providing heat to at least a portion of a hydrocarbon containing formation such that a temperature (T) in a substantial part of the heated portion exceeds 270 °C and hydrocarbons are pyrolyzed within the heated portion of the formation;
controlling a pressure (p) within at least a substantial part of the heated portion of the formation;

15 wherein $p_{bar} > e^{\{(-A/T) + B - 2.6744\}}$;

wherein p is the pressure in bar absolute and T is the temperature in degrees K, and A and B are parameters that are larger than 10 and are selected in relation to the characteristics and composition of the hydrocarbon containing formation and on the required olefin content and carbon number of the pyrolyzed hydrocarbon fluids; and producing pyrolyzed hydrocarbon fluids from the heated portion of the formation.

20 611. The method of claim 610, wherein A is greater than 14000 and B is greater than about 25 and a majority of the produced pyrolyzed hydrocarbon fluids have an average carbon number lower than 25 and comprise less than about 10 % by weight of olefins.

25 612. The method of claim 610, wherein T is less than about 390 °C, p is greater than about 1.4 bar, A is greater than about 44000, and b is greater than about 67, and a majority of the produced pyrolyzed hydrocarbon fluids have an average carbon number less than 25 and comprise less than 10 % by weight of olefins.

30 613. The method of claim 610, wherein T is less than about 390 °C, p is greater than about 2 bar, A is less than about 57000, and b is less than about 83, and a majority of the

produced pyrolyzed hydrocarbon fluids have an average carbon number lower than about 21.

614. The method of claim 610, further comprising controlling the heat such that an
5 average heating rate of the heated portion is less than about 3°C per day during
pyrolysis.

615. The method of claim 610, wherein providing heat from the one or more heat
sources to at least the portion of formation comprises:

10 heating a selected volume (V) of the hydrocarbon containing formation from the
one or more heat sources, wherein the formation has an average heat capacity (C_v), and
wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of
the formation; and

15 wherein heating energy/day provided to the volume is equal to or less than Pwr ,
wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the
formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10
°C/day.

20 616. The method of claim 610, wherein heat is transferred substantially by conduction
from one or more heat sources located in one or more heat sources to the heated portion
of the formation.

25 617. The method of claim 616, wherein the heat sources comprise heaters in which
hydrocarbons are either injected into a heaters or released by the hydrocarbon containing
formation adjacent to a heater by an oxidant injected into the heater in or adjacent to
which the combustion occurs and wherein at least part of the produced combustion gases
are vented to surface via the heater in which the combustion occurs.

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618. The method of claim 617, wherein heat is transferred substantially by conduction from one or more heat sources to the heated portion of the formation such that the thermal conductivity of at least part of the heated portion is substantially uniformly modified to a value greater than about 0.6 W/m °C and the permeability of said part increases substantially uniformly to a value greater than 1 Darcy.

5

619. The method of claim 610, further comprising controlling formation conditions to produce a mixture of hydrocarbon fluids and H₂, wherein a partial pressure of H₂ within the mixture flowing through the formation is greater than 0.5 Bar.

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620. The method of claim 619, further comprising, hydrogenating a portion of the produced pyrolyzed hydrocarbon fluids with at least a portion of the produced hydrogen and heating the fluids with heat from hydrogenation.

15

621. The method of claim 610, wherein the hydrocarbon containing formation is a coal seam and at least about 70% of the hydrocarbon content of the coal, when such hydrocarbon content is measured by a Fischer assay, is produced from the heated portion of the formation.

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622. The method of claim 610, wherein the substantially gaseous pyrolyzed hydrocarbon fluids are produced from a production well, the method further comprising heating a wellbore of the production well to inhibit condensation of the hydrocarbon fluids within the wellbore.

25

623. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation to raise an average temperature within the selected section to, or above, a temperature that will pyrolyze hydrocarbons within the selected section;
producing a mixture from the formation; and

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controlling a weight percentage of olefins of the produced mixture to be less than about 20 % by weight by controlling average pressure and average temperature in the selected section such that the average pressure in the selected section is greater than the pressure (p) set forth in the following equation for an assessed average temperature (T) in the selected section:

$$p = e^{[-57000/T + 83]}$$

where p is measured in psia and T is measured in ° Kelvin.

10 624. The method of claim 623, wherein the weight percentage of olefins of the produced mixture is controlled to be less than about 10 % by weight, and wherein the equation is:

$$p = e^{[-16000/T + 28]}$$

15 625. The method of claim 623, wherein the weight percentage of olefins of the produced mixture is controlled to be less than about 5 % by weight, and wherein the equation is:

$$p = e^{[-12000/T + 22]}$$

20 626. The method of claim 623, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

25 627. The method of claim 623, wherein the one or more heat sources comprise electrical heaters.

628. The method of claim 623, wherein the one or more heat sources comprise surface burners.

30 629. The method of claim 623, wherein the one or more heat sources comprise flameless distributed combustors.

630. The method of claim 623, wherein the one or more heat sources comprise natural distributed combustors.

631. The method of claim 623, further comprising controlling a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

632. The method of claim 631, wherein controlling an average temperature comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

633. The method of claim 623, further comprising controlling the heat such that an average heating rate of the selected section is less than about 3.0 °C per day during pyrolysis.

634. The method of claim 623, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

635. The method of claim 623, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than P_{wr} , wherein P_{wr} is calculated by the equation:

$$P_{wr} = h * V * C_v * \rho_B$$

wherein P_{wr} is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

5 636. The method of claim 623, wherein allowing the heat to transfer comprises
transferring heat substantially by conduction.

10 637. The method of claim 623, wherein providing heat from the one or more heat
sources comprises heating the selected formation such that a thermal conductivity of at
least a portion of the selected section is greater than about 0.5 W/(m °C).

15 638. The method of claim 623, wherein the produced mixture comprises condensable
hydrocarbons having an API gravity of at least about 25°.

20 639. The method of claim 623, wherein the produced mixture comprises condensable
hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the
condensable hydrocarbons are olefins.

25 640. The method of claim 623, wherein the produced mixture comprises non-
condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight
of the non-condensable hydrocarbons are olefins.

641. The method of claim 623, wherein the produced mixture comprises non-
condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-
condensable hydrocarbons ranges from about 0.001 to about 0.15.

642. The method of claim 623, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is nitrogen.

643. The method of claim 623, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

5 644. The method of claim 623, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

10 645. The method of claim 623, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

15 646. The method of claim 623, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

20 647. The method of claim 623, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

25 648. The method of claim 623, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

649. The method of claim 623, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 650. The method of claim 623, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen,

wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

5 651. The method of claim 623, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

652. The method of claim 623, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

10 653. The method of claim 623, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

15 654. The method of claim 623, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

20 655. The method of claim 623, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

656. The method of claim 623, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

25 657. The method of claim 623, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

658. The method of claim 623, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

5 659. The method of claim 623, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

10 660. The method of claim 623, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

15 661. The method of claim 623, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

662. The method of claim 623, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 663. The method of claim 623, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 664. The method of claim 623, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30 665. A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heat sources to at least a portion of the formation;

allowing the heat to transfer from the one or more heat sources to a selected section of the formation to raise an average temperature within the selected section to, or above, a temperature that will pyrolyze hydrocarbons within the selected section;

producing a mixture from the formation; and

controlling hydrocarbons having carbon numbers greater than 25 of the produced mixture to be less than about 25 % by weight by controlling average pressure and average temperature in the selected section such that the average pressure in the selected section is greater than the pressure (p) set forth in the following equation for an assessed average temperature (T) in the selected section:

$$p = e^{[-14000/T + 25]}$$

where p is measured in psia and T is measured in ° Kelvin.

666. The method of claim 662, wherein the hydrocarbons having carbon numbers greater than 25 of the produced mixture is controlled to be less than about 20 % by weight, and wherein the equation is:

$$p = e^{[-16000/T + 28]}$$

667. The method of claim 662, wherein the hydrocarbons having carbon numbers greater than 25 of the produced mixture is controlled to be less than about 15 % by weight, and wherein the equation is:

$$p = e^{[-18000/T + 32]}$$

668. The method of claim 662, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

669. The method of claim 662, wherein the one or more heat sources comprise electrical heaters.

670. The method of claim 662, wherein the one or more heat sources comprise surface burners.

671. The method of claim 662, wherein the one or more heat sources comprise
5 flameless distributed combustors.

672. The method of claim 662, wherein the one or more heat sources comprise natural distributed combustors.

10 673. The method of claim 662, further comprising controlling a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

15 674. The method of claim 673, wherein controlling the temperature comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

20 675. The method of claim 662, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

676. The method of claim 662, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

25 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

30 wherein heating energy/day provided to the volume is equal to or less than P_{wr} , wherein P_{wr} is calculated by the equation:

$$P_{wr} = h * V * C_v * \rho_B$$

wherein P_{wr} is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

5 677. The method of claim 662, wherein allowing the heat to transfer comprises
transferring heat substantially by conduction.

10 678. The method of claim 662, wherein providing heat from the one or more heat
sources comprises heating the selected section such that a thermal conductivity of at least
a portion of the selected section is greater than about 0.5 W/(m °C).

15 679. The method of claim 662, wherein the produced mixture comprises condensable
hydrocarbons having an API gravity of at least about 25°.

20 680. The method of claim 662, wherein the produced mixture comprises condensable
hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the
condensable hydrocarbons are olefins.

25 681. The method of claim 662, wherein the produced mixture comprises non-
condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-
condensable hydrocarbons ranges from about 0.001 to about 0.15.

30 682. The method of claim 662, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is nitrogen.

683. The method of claim 662, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is oxygen.

684. The method of claim 662, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5 685. The method of claim 662, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

10 686. The method of claim 662, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

15 687. The method of claim 662, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

20 688. The method of claim 662, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

25 689. The method of claim 662, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 690. The method of claim 662, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

691. The method of claim 662, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5 692. The method of claim 662, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

10 693. The method of claim 662, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

15 694. The method of claim 662, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

20 695. The method of claim 662, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

25 696. The method of claim 662, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

697. The method of claim 662, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

30 698. The method of claim 662, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

699. The method of claim 662, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

700. The method of claim 662, further comprising controlling the heat to yield greater
5 than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

701. The method of claim 662, wherein producing the mixture comprises producing
10 the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

702. The method of claim 662, further comprising providing heat from three or more
15 heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

703. The method of claim 662, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat
sources are located in the formation in a unit of heat sources, wherein the unit of heat
sources comprises a triangular pattern, and wherein a plurality of the units are repeated
20 over an area of the formation to form a repetitive pattern of units.

704. A method of treating a hydrocarbon containing formation in situ, comprising:
25 providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation to raise an average temperature within the selected section to, or above, a temperature that will pyrolyze hydrocarbons within the selected section;
producing a mixture from the formation; and
30 controlling an atomic hydrogen to carbon ratio of the produced mixture to be greater than about 1.7 by controlling average pressure and average temperature in the

selected section such that the average pressure in the selected section is greater than the pressure (p) set forth in the following equation for an assessed average temperature (T) in the selected section:

$$p = e^{[-38000/T + 61]}$$

5

where p is measured in psia and T is measured in ° Kelvin.

705. The method of claim 704, wherein the atomic hydrogen to carbon ratio of the produced mixture is controlled to be greater than about 1.8, and wherein the equation is:

$$p = e^{[-13000/T + 24]}$$

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706. The method of claim 704, wherein the atomic hydrogen to carbon ratio of the produced mixture is controlled to be greater than about 1.9, and wherein the equation is:

$$p = e^{[-8000/T + 18]}$$

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707. The method of claim 704, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

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708. The method of claim 704, wherein the one or more heat sources comprise electrical heaters.

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709. The method of claim 704, wherein the one or more heat sources comprise surface burners.

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710. The method of claim 704, wherein the one or more heat sources comprise flameless distributed combustors.

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711. The method of claim 704, wherein the one or more heat sources comprise natural distributed combustors.

712. The method of claim 704, further comprising controlling a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

5

713. The method of claim 712, wherein controlling the temperature comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

10 714. The method of claim 704, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

15 715. The method of claim 704, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

20 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

25 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

716. The method of claim 704, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

717. The method of claim 704, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

5 718. The method of claim 704, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

10 719. The method of claim 704, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

15 720. The method of claim 704, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

20 721. The method of claim 704, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

25 722. The method of claim 704, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

723. The method of claim 704, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

30 724. The method of claim 704, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

725. The method of claim 704, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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726. The method of claim 704, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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727. The method of claim 704, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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728. The method of claim 704, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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729. The method of claim 704, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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730. The method of claim 704, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

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731. The method of claim 704, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

732. The method of claim 704, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

733. The method of claim 704, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

734. The method of claim 704, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

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735. The method of claim 704, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

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736. The method of claim 704, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

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737. The method of claim 704, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

25

738. The method of claim 704, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

30

739. The method of claim 704, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

740. The method of claim 704, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

741. The method of claim 704, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

742. The method of claim 704, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

743. The method of claim 704, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

744. The method of claim 704, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

745. A method of treating a hydrocarbon containing formation in situ, comprising:
25 providing heat from one or more heat sources to at least one portion of the formation;

allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

30 controlling a pressure-temperature relationship within at least the selected section of the formation by selected energy input into the one or more heat sources and by pressure release from the selected section through wellbores of the one or more heat sources; and

producing a mixture from the formation.

746. The method of claim 745, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

747. The method of claim 745, wherein the one or more heat sources comprise at least two heat sources.

10 748. The method of claim 745, wherein the one or more heat sources comprise surface burners.

15 749. The method of claim 745, wherein the one or more heat sources comprise flameless distributed combustors.

750. The method of claim 745, wherein the one or more heat sources comprise natural distributed combustors.

20 751. The method of claim 745, further comprising controlling the pressure-temperature relationship by controlling a rate of removal of fluid from the formation.

25 752. The method of claim 745, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

753. The method of claim 745, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

754. The method of claim 745, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

755. The method of claim 745, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

756. The method of claim 745, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

757. The method of claim 745, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

758. The method of claim 745, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

759. The method of claim 745, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

760. The method of claim 745, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

5 761. The method of claim 745, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

10 762. The method of claim 745, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

15 763. The method of claim 745, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

20 764. The method of claim 745, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

25 765. The method of claim 745, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

766. The method of claim 745, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

767. The method of claim 745, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5 768. The method of claim 745, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

10 769. The method of claim 745, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

15 770. The method of claim 745, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

20 771. The method of claim 745, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

25 772. The method of claim 745, further comprising controlling formation conditions to produce a mixture of hydrocarbon fluids and H₂, wherein the partial pressure of H₂ within the mixture is greater than about 0.5 bar.

773. The method of claim 745, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 774. The method of claim 745, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

775. The method of claim 745, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5 776. The method of claim 745, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

777. The method of claim 745, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons
10 within the section; and
heating a portion of the section with heat from hydrogenation.

15 778. The method of claim 745, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

779. The method of claim 745, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

20 780. The method of claim 745, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

25 781. The method of claim 745, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

30 782. The method of claim 745, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

783. The method of claim 745, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

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784. The method of claim 745, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

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785. A method of treating a hydrocarbon containing formation in situ, comprising: heating a selected volume (V) of the hydrocarbon containing formation, wherein formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

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wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

20

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

786. The method of claim 785, wherein heating a selected volume comprises heating with an electrical heater.

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787. The method of claim 785, wherein heating a selected volume comprises heating with a surface burner.

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788. The method of claim 785, wherein heating a selected volume comprises heating with a flameless distributed combustor.

789. The method of claim 785, wherein heating a selected volume comprises heating with a natural distributed combustors.

790. The method of claim 785, further comprising controlling a pressure and a 5 temperature within at least a majority of the selected volume of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

791. The method of claim 785, further comprising controlling the heating such that an 10 average heating rate of the selected volume is less than about 1 °C per day during pyrolysis.

792. The method of claim 785, wherein a value for C_v is determined as an average heat 15 capacity of two or more samples taken from the hydrocarbon containing formation.

793. The method of claim 785, wherein heating the selected volume comprises transferring heat substantially by conduction.

794. The method of claim 785, wherein heating the selected volume comprises heating 20 the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

795. The method of claim 785, wherein the produced mixture comprises condensable 25 hydrocarbons having an API gravity of at least about 25°.

796. The method of claim 785, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

797. The method of claim 785, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

5 798. The method of claim 785, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

10 799. The method of claim 785, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

15 800. The method of claim 785, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

801. The method of claim 785, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

20 802. The method of claim 785, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

25 803. The method of claim 785, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

804. The method of claim 785, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

5 805. The method of claim 785, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

10 806. The method of claim 785, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

15 807. The method of claim 785, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

20 808. The method of claim 785, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

809. The method of claim 785, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer

25 810. The method of claim 785, further comprising controlling a pressure within at least a majority of the selected volume of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

30 811. The method of claim 785, further comprising controlling formation conditions to produce a mixture from the formation comprising condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

812. The method of claim 785, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

5 813. The method of claim 785, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

10 814. The method of claim 785, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

15 815. The method of claim 785, further comprising:
providing hydrogen (H₂) to the heated volume to hydrogenate hydrocarbons within the volume; and
heating a portion of the volume with heat from hydrogenation.

20 816. The method of claim 785, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

25 817. The method of claim 785, further comprising increasing a permeability of a majority of the selected volume to greater than about 100 millidarcy.

818. The method of claim 785, further comprising substantially uniformly increasing a permeability of a majority of the selected volume.

30 819. The method of claim 785, further comprising controlling the heat to yield greater than about 60% by weight of condensable hydrocarbons, as measured by the Fischer Assay.

820. The method of claim 785, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

5 821. The method of claim 785, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

10 822. The method of claim 785, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

15 823. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;

20 allowing the heat to transfer from the one or more heat sources to a selected section of the formation to raise an average temperature within the selected section to, or above, a temperature that will pyrolyze hydrocarbons within the selected section;

controlling heat output from the one or more heat sources such that an average heating rate of the selected section rises by less than about 3 °C per day when the average temperature of the selected section is at, or above, the temperature that will pyrolyze hydrocarbons within the selected section; and

25 producing a mixture from the formation.

824. The method of claim 823, controlling heat output comprises:
raising the average temperature within the selected section to a first temperature that is at or above a minimum pyrolysis temperature of hydrocarbons within the formation;

limiting energy input into the one or more heat sources to inhibit increase in temperature of the selected section; and

increasing energy input into the formation to raise an average temperature of the selected section above the first temperature when production of formation fluid declines below a desired production rate.

825. The method of claim 823, controlling heat output comprises:

raising the average temperature within the selected section to a first temperature that is at or above a minimum pyrolysis temperature of hydrocarbons within the formation;

limiting energy input into the one or more heat sources to inhibit increase in temperature of the selected section; and

increasing energy input into the formation to raise an average temperature of the selected section above the first temperature when quality of formation fluid produced from the formation falls below a desired quality.

826. The method of claim 823, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section.

827. The method of claim 823, wherein the one or more heat sources comprise electrical heaters.

828. The method of claim 823, wherein the one or more heat sources comprise surface burners.

829. The method of claim 823, wherein the one or more heat sources comprise flameless distributed combustors.

830. The method of claim 823, wherein the one or more heat sources comprise natural distributed combustors.

831. The method of claim 823, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

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832. The method of claim 823, wherein the heat is controlled that an average heating rate of the selected section is less than about 1.5 °C per day during pyrolysis.

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833. The method of claim 823, wherein the heat is controlled that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

15 834. The method of claim 823, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

20 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

25 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density.

25

835. The method of claim 823, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

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836. The method of claim 823, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

837. The method of claim 823, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

838. The method of claim 823, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

839. The method of claim 823, wherein the produced mixture comprises condensable hydrocarbons, wherein the condensable hydrocarbons have an olefin content is less than about 2.5 % by weight of the condensable hydrocarbons, and wherein the olefin content is greater than about 0.1 % by weight of the condensable hydrocarbons.

840. The method of claim 823, wherein the produced mixture comprises non-condensable hydrocarbons, wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons is less than about 0.15, and wherein the ratio of ethene to ethane is greater than about 0.001.

841. The method of claim 823, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons is less than about 0.10 and wherein the ratio of ethene to ethane is greater than about 0.001.

842. The method of claim 823, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons is less than about 0.05 and wherein the ratio of ethene to ethane is greater than about 0.001.

843. The method of claim 823, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

844. The method of claim 823, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

5 845. The method of claim 823, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

10 846. The method of claim 823, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

15 847. The method of claim 823, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

20 848. The method of claim 823, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

25 849. The method of claim 823, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

850. The method of claim 823, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 851. The method of claim 823, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen,

wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

5 852. The method of claim 823, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

853. The method of claim 823, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

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854. The method of claim 823, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

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855. The method of claim 823, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

20

856. The method of claim 823, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

25

857. The method of claim 823, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

858. The method of claim 823, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

30

859. The method of claim 823, further comprising:

providing H₂ to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

5 860. The method of claim 823, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

10 861. The method of claim 823, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

15 862. The method of claim 823, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

863. The method of claim 823, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

20 864. The method of claim 823, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

25 865. The method of claim 823, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

30 866. The method of claim 823, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat

sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

867. A method of treating a hydrocarbon containing formation in situ, comprising:

5 providing heat from one or more heat sources to at least a portion of the formation; to heat a selected section of the formation to an average temperature above about 270 °C;

allowing the heat to transfer from the one or more heat sources to the selected section of the formation;

10 controlling the heat from the one or more heat sources such that an average heating rate of the selected section is less than about 3 °C per day during pyrolysis; and producing a mixture from the formation.

868. The method of claim 867, wherein the one or more heat sources comprise at least 15 two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

869. The method of claim 867, wherein the one or more heat sources comprise 20 electrical heaters.

870. The method of claim 867, further comprising supplying electricity to the electrical 25 heaters substantially during non-peak hours.

871. The method of claim 867, wherein the one or more heat sources comprise surface 30 burners.

872. The method of claim 867, wherein the one or more heat sources comprise flameless distributed combustors.

873. The method of claim 867, wherein the one or more heat sources comprise natural 35 distributed combustors.

874. The method of claim 867, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

875. The method of claim 867, wherein the heat is further controlled such that an average heating rate of the selected section is less than about 3 °C/day until production of condensable hydrocarbons substantially ceases.

876. The method of claim 867, wherein the heat is further controlled that an average heating rate of the selected section is less than about 1.5 °C per day during pyrolysis.

877. The method of claim 867, wherein the heat is further controlled such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

878. The method of claim 867, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density.

879. The method of claim 867, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

880. The method of claim 867, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

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881. The method of claim 867, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

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882. The method of claim 867, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

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883. The method of claim 867, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

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884. The method of claim 867, wherein the produced mixture comprises non-condensable hydrocarbons, wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons is less than about 0.15, and wherein the ratio of ethene to ethane is greater than about 0.001.

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885. The method of claim 867, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

886. The method of claim 867, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

887. The method of claim 867, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5 888. The method of claim 867, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

10 889. The method of claim 867, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

15 890. The method of claim 867, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

20 891. The method of claim 867, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

25 892. The method of claim 867, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 893. The method of claim 867, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

894. The method of claim 867, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

895. The method of claim 867, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

896. The method of claim 867, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

897. The method of claim 867, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

898. The method of claim 897, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

899. The method of claim 867, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

900. The method of claim 867, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

901. The method of claim 867, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

902. The method of claim 867, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

5 903. The method of claim 867, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

10 904. The method of claim 867, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

15 905. The method of claim 867, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

906. The method of claim 867, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 907. The method of claim 867, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 908. The method of claim 867, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30 909. A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heat sources to at least a portion of the formation;

allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

5 producing a mixture from the formation through at least one production well; monitoring a temperature at or in the production well; and controlling heat input to raise the monitored temperature at a rate of less than about 3 °C per day.

10 910. The method of claim 909, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

15 911. The method of claim 909, wherein the one or more heat sources comprise electrical heaters.

912. The method of claim 909, wherein the one or more heat sources comprise surface burners.

20 913. The method of claim 909, wherein the one or more heat sources comprise flameless distributed combustors.

914. The method of claim 909, wherein the one or more heat sources comprise natural distributed combustors.

25 915. The method of claim 909, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

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916. The method of claim 909, wherein the heat is controlled that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

917. The method of claim 909, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density.

918. The method of claim 909, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

919. The method of claim 909, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

920. The method of claim 909, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

921. The method of claim 909, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

922. The method of claim 909, wherein the produced mixture comprises non-condensable hydrocarbons, wherein a molar ratio of ethene to ethane in the non-

condensable hydrocarbons is less than about 0.15, and wherein the ratio of ethene to ethane is greater than about 0.001.

923. The method of claim 909, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

924. The method of claim 909, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

925. The method of claim 909, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

926. The method of claim 909, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

927. The method of claim 909, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

928. The method of claim 909, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

929. The method of claim 909, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

930. The method of claim 909, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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931. The method of claim 909, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

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932. The method of claim 909, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

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933. The method of claim 909, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

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934. The method of claim 909, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

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935. The method of claim 909, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

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936. The method of claim 935, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

937. The method of claim 909, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

938. The method of claim 909, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

5 939. The method of claim 909, further comprising:
providing H₂ to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

10 940. The method of claim 909, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

15 941. The method of claim 909, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

20 942. The method of claim 909, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

943. The method of claim 909, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

25 944. The method of claim 909, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

30 945. The method of claim 909, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat

sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

946. The method of claim 909, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

10 947. A method of treating a hydrocarbon containing formation in situ, comprising:
heating a portion of the formation to a temperature sufficient to support oxidation of hydrocarbons within the portion, wherein the portion is located substantially adjacent to a wellbore;

15 flowing an oxidant through a conduit positioned within the wellbore to a heat source zone within the portion, wherein the heat source zone supports an oxidation reaction between hydrocarbons and the oxidant;

reacting a portion of the oxidant with hydrocarbons to generate heat; and
transferring generated heat substantially by conduction to a pyrolysis zone of the formation to pyrolyze at least a portion of the hydrocarbons within the pyrolysis zone.

20 948. The method of claim 947, wherein heating the portion of the formation comprises raising a temperature of the portion above about 400 °C.

25 949. The method of claim 947, wherein the conduit comprises critical flow orifices, the method further comprising flowing the oxidant through the critical flow orifices to the heat source zone.

950. The method of claim 947, further comprising removing reaction products from the heat source zone through the wellbore.

951. The method of claim 947, further comprising removing excess oxidant from the heat source zone to inhibit transport of the oxidant to the pyrolysis zone.

5 952. The method of claim 947, further comprising transporting the oxidant from the conduit to the heat source zone substantially by diffusion.

953. The method of claim 947, further comprising heating the conduit with reaction products being removed through the wellbore.

10 954. The method of claim 947, wherein the oxidant comprises hydrogen peroxide.

955. The method of claim 947, wherein the oxidant comprises air.

15 956. The method of claim 947, wherein the oxidant comprises a fluid substantially free of nitrogen.

957. The method of claim 947, further comprising limiting an amount of oxidant to maintain a temperature of the heat source zone less than about 1200 °C.

20 958. The method of claim 947, wherein heating the portion of the formation comprises electrically heating the formation.

959. The method of claim 947, wherein heating the portion of the formation comprises heating the portion using exhaust gases from a surface burner.

25 960. The method of claim 947, wherein heating the portion of the formation comprises heating the portion with a flameless distributed combustor.

961. The method of claim 947, further comprising controlling a pressure and a temperature within at least a majority of the pyrolysis zone, wherein the pressure is

controlled as a function of temperature, or the temperature is controlled as a function of pressure.

962. The method of claim 947, further comprising controlling the heat such that an
5 average heating rate of the pyrolysis zone is less than about 1 °C per day during pyrolysis.

963. The method of claim 947, wherein heating the portion comprises heating the pyrolysis zone such that a thermal conductivity of at least a portion of the pyrolysis zone is greater than about 0.5 W/(m °C).

10 964. The method of claim 947, further comprising controlling a pressure within at least a majority of the pyrolysis zone of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

15 965. The method of claim 947, further comprising:
providing hydrogen (H₂) to the pyrolysis zone to hydrogenate hydrocarbons within the pyrolysis zone; and
heating a portion of the pyrolysis zone with heat from hydrogenation.

20 966. The method of claim 947, wherein transferring generated heat comprises increasing a permeability of a majority of the pyrolysis zone to greater than about 100 millidarcy.

25 967. The method of claim 947, wherein transferring generated heat comprises substantially uniformly increasing a permeability of a majority of the pyrolysis zone.

968. The method of claim 947, wherein the heating is controlled to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

30 969. The method of claim 947, wherein the wellbore is located along strike to reduce pressure differentials along a heated length of the wellbore.

970. The method of claim 947, wherein the wellbore is located along strike to increase uniformity of heating along a heated length of the wellbore.

5 971. The method of claim 947, wherein the wellbore is located along strike to increase control of heating along a heated length of the wellbore.

10 972. A method of treating a hydrocarbon containing formation in situ, comprising:
heating a portion of the formation to a temperature sufficient to support reaction
of hydrocarbons within the portion of the formation with an oxidant;
flowing the oxidant into a conduit, and wherein the conduit is connected such that
the oxidant can flow from the conduit to the hydrocarbons;
allowing the oxidant and the hydrocarbons to react to produce heat in a heat
source zone;
15 allowing heat to transfer from the heat source zone to a pyrolysis zone in the
formation to pyrolyze at least a portion of the hydrocarbons within the pyrolysis zone;
and
removing reaction products such that the reaction products are inhibited from
flowing from the heat source zone to the pyrolysis zone.

20 973. The method of claim 972, wherein heating the portion of the formation comprises
raising the temperature of the portion above about 400 °C.

25 974. The method of claim 972, wherein heating the portion of the formation comprises
electrically heating the formation.

975. The method of claim 972, wherein heating the portion of the formation comprises
heating the portion using exhaust gases from a surface burner.

976. The method of claim 972, wherein the conduit comprises critical flow orifices, the method further comprising flowing the oxidant through the critical flow orifices to the heat source zone.

5 977. The method of claim 972, wherein the conduit is located within a wellbore, wherein removing reaction products comprises removing reaction products from the heat source zone through the wellbore.

10 978. The method of claim 972, further comprising removing excess oxidant from the heat source zone to inhibit transport of the oxidant to the pyrolysis zone.

15 979. The method of claim 972, further comprising transporting the oxidant from the conduit to the heat source zone substantially by diffusion.

980. The method of claim 972, wherein the conduit is located within a wellbore, the method further comprising heating the conduit with reaction products being removed through the wellbore to raise a temperature of the oxidant passing through the conduit.

20 981. The method of claim 972, wherein the oxidant comprises hydrogen peroxide.

982. The method of claim 972, wherein the oxidant comprises air.

25 983. The method of claim 972, wherein the oxidant comprises a fluid substantially free of nitrogen.

984. The method of claim 972, further comprising limiting an amount of oxidant to maintain a temperature of the heat source zone less than about 1200 °C.

30 985. The method of claim 972, further comprising limiting an amount of oxidant to maintain a temperature of the heat source zone at a temperature that inhibits production of oxides of nitrogen.

986. The method of claim 972, wherein heating a portion of the formation to a temperature sufficient to support oxidation of hydrocarbons within the portion further comprises heating with a flameless distributed combustor.

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987. The method of claim 972, further comprising controlling a pressure and a temperature within at least a majority of the pyrolysis zone of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

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988. The method of claim 972, further comprising controlling the heat such that an average heating rate of the pyrolysis zone is less than about 1 °C per day during pyrolysis.

989. The method of claim 972, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

15

990. The method of claim 972, wherein allowing heat to transfer comprises heating the pyrolysis zone such that a thermal conductivity of at least a portion of the pyrolysis zone is greater than about 0.5 W/(m °C).

20

991. The method of claim 972, further comprising controlling a pressure within at least a majority of the pyrolysis zone, wherein the controlled pressure is at least about 2.0 bar absolute.

25

992. The method of claim 972, further comprising:

providing hydrogen (H_2) to the pyrolysis zone to hydrogenate hydrocarbons within the pyrolysis zone; and

heating a portion of the pyrolysis zone with heat from hydrogenation.

993. The method of claim 972, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the pyrolysis zone to greater than about 100 millidarcy.

5 994. The method of claim 972, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the pyrolysis zone.

10 995. The method of claim 972, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

15 996. An in situ method for heating a hydrocarbon containing formation, comprising: heating a portion of the formation to a temperature sufficient to support reaction of hydrocarbons within the portion of the formation with an oxidizing fluid, wherein the portion is located substantially adjacent to an opening in the formation; providing the oxidizing fluid to a heat source zone in the formation; allowing the oxidizing gas to react with at least a portion of the hydrocarbons at the heat source zone to generate heat in the heat source zone; and transferring the generated heat substantially by conduction from the heat source zone to a pyrolysis zone in the formation.

20 997. The method of claim 996, further comprising transporting the oxidizing fluid through the heat source zone by diffusion.

25 998. The method of claim 996, further comprising directing at least a portion of the oxidizing fluid into the opening through orifices of a conduit disposed in the opening.

30 999. The method of claim 996, further comprising controlling a flow of the oxidizing fluid with critical flow orifices of a conduit disposed in the opening such that a rate of oxidation is controlled.

1000. The method of claim 996, wherein a conduit is disposed within the opening, the method further comprising removing an oxidation product from the formation through the conduit.

5 1001. The method of claim 996, wherein a conduit is disposed within the opening, the method further comprising removing an oxidation product from the formation through the conduit and transferring substantial heat from the oxidation product in the conduit to the oxidizing fluid in the conduit.

10 1002. The method of claim 996, wherein a conduit is disposed within the opening, the method further comprising removing an oxidation product from the formation through the conduit, wherein a flow rate of the oxidizing fluid in the conduit is approximately equal to a flow rate of the oxidation product in the conduit.

15 1003. The method of claim 996, wherein a conduit is disposed within the opening, the method further comprising removing an oxidation product from the formation through the conduit and controlling a pressure between the oxidizing fluid and the oxidation product in the conduit to reduce contamination of the oxidation product by the oxidizing fluid.

20 1004. The method of claim 996, wherein a center conduit is disposed within an outer conduit, and wherein the outer conduit is disposed within the opening, the method further comprising providing the oxidizing fluid into the opening through the center conduit and removing an oxidation product through the outer conduit.

25 1005. The method of claim 996, wherein the heat source zone extends radially from the opening a width of less than approximately 0.15 m.

30 1006. The method of claim 996, wherein heating the portion comprises applying electrical current to an electric heater disposed within the opening.

1007. The method of claim 996, wherein the pyrolysis zone is substantially adjacent to the heat source zone.

1008. The method of claim 996, further comprising controlling a pressure and a temperature within at least a majority of the pyrolysis zone of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1009. The method of claim 996, further comprising controlling the heat such that an average heating rate of the pyrolysis zone is less than about 1 °C per day during pyrolysis.

1010. The method of claim 996, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

15 1011. The method of claim 996, wherein allowing heat to transfer comprises heating the portion such that a thermal conductivity of at least a portion of the pyrolysis zone is greater than about 0.5 W/(m °C).

20 1012. The method of claim 996, further comprising controlling a pressure within at least a majority of the pyrolysis zone, wherein the controlled pressure is at least about 2.0 bar absolute.

25 1013. The method of claim 996, further comprising:
providing hydrogen (H₂) to the pyrolysis zone to hydrogenate hydrocarbons within the pyrolysis zone; and
heating a portion of the pyrolysis zone with heat from hydrogenation.

30 1014. The method of claim 996, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the pyrolysis zone to greater than about 100 millidarcy.

1015. The method of claim 996, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the pyrolysis zone.

1016. The method of claim 996, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

1017. A method of treating a hydrocarbon containing formation in situ, comprising: providing heat from one or more heat sources to at least a portion of the formation;

10 allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

15 producing a mixture from the formation; and

15 maintaining an average temperature within the selected section above a minimum pyrolysis temperature and below a vaporization temperature of hydrocarbons having carbon numbers greater than 25 to inhibit production of a substantial amount of hydrocarbons having carbon numbers greater than 25 in the mixture.

20 1018. The method of claim 1017, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

25 1019. The method of claim 1017, wherein maintaining the average temperature within the selected section comprises maintaining the temperature within a pyrolysis temperature range.

30 1020. The method of claim 1017, wherein the one or more heat sources comprise electrical heaters.

1021. The method of claim 1017, wherein the one or more heat sources comprise surface burners.

5 1022. The method of claim 1017, wherein the one or more heat sources comprise flameless distributed combustors.

1023. The method of claim 1017, wherein the one or more heat sources comprise natural distributed combustors.

10 1024. The method of claim 1017, wherein the minimum pyrolysis temperature is greater than about 270 °C.

15 1025. The method of claim 1017, wherein the vaporization temperature is less than approximately 450 °C at atmospheric pressure.

1026. The method of claim 1017, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

20 1027. The method of claim 1017, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

25 1028. The method of claim 1017, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

30 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than P_{wr} , wherein P_{wr} is calculated by the equation:

$$P_{wr} = h * V * C_v * \rho_B$$

5 wherein P_{wr} is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

1029. The method of claim 1017, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

10 1030. The method of claim 1017, wherein providing heat from the one or more heat sources comprises heating the selected formation such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

15 1031. The method of claim 1017, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

20 1032. The method of claim 1017, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

25 1033. The method of claim 1017, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

1034. The method of claim 1017, wherein the produced mixture comprises non-condensable hydrocarbons, wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons is less than about 0.15, and wherein the ratio of ethene to ethane is greater than about 0.001.

30

1035. The method of claim 1017, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

5 1036. The method of claim 1017, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

10 1037. The method of claim 1017, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

15 1038. The method of claim 1017, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

20 1039. The method of claim 1017, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

25 1040. The method of claim 1017, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

1041. The method of claim 1017, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

1042. The method of claim 1017, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5 1043. The method of claim 1017, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

10 1044. The method of claim 1017, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

15 1045. The method of claim 1017, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

20 1046. The method of claim 1017, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

25 1047. The method of claim 1017, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 1048. The method of claim 1047, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

1049. The method of claim 1017, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

1050. The method of claim 1017, further comprising:

providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

5 1051. The method of claim 1017, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

10 1052. The method of claim 1017, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

15 1053. The method of claim 1017, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

1054. The method of claim 1017, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

20 1055. The method of claim 1017, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

25 1056. The method of claim 1017, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

30 1057. The method of claim 1017, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat

sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

1058. A method of treating a hydrocarbon containing formation in situ, comprising:

5 providing heat from one or more heat sources to at least a portion of the formation;

allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

10 controlling a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than 25; and producing a mixture from the formation.

1059. The method of claim 1058, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

1060. The method of claim 1058, wherein the one or more heat sources comprise electrical heaters.

20 1061. The method of claim 1058, wherein the one or more heat sources comprise surface burners.

25 1062. The method of claim 1058, wherein the one or more heat sources comprise flameless distributed combustors.

1063. The method of claim 1058, wherein the one or more heat sources comprise natural distributed combustors.

30 1064. The method of claim 1058, further comprising controlling a temperature within at least a majority of the selected section of the formation, wherein the pressure is

controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1065. The method of claim 1064, wherein controlling the temperature comprises
5 maintaining a temperature within the selected section within a pyrolysis temperature range.

1066. The method of claim 1058, further comprising controlling the heat such that an
average heating rate of the selected section is less than about 1 °C per day during
10 pyrolysis.

1067. The method of claim 1058, wherein providing heat from the one or more heat
sources to at least the portion of formation comprises:

15 heating a selected volume (V) of the hydrocarbon containing formation from the
one or more heat sources, wherein the formation has an average heat capacity (C_v), and
wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of
the formation; and

20 wherein heating energy/day provided to the volume is equal to or less than Pwr ,
wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

25 wherein Pwr is the heating energy/day, h is an average heating rate of the
formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10
°C/day.

1068. The method of claim 1058, wherein allowing the heat to transfer comprises
transferring heat substantially by conduction.

1069. The method of claim 1058, wherein providing heat from the one or more heat
sources comprises heating the selected formation such that a thermal conductivity of at
30 least a portion of the selected section is greater than about 0.5 W/(m °C).

1070. The method of claim 1058, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

1071. The method of claim 1058, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

1072. The method of claim 1058, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

15 1073. The method of claim 1058, wherein the produced mixture comprises non-condensable hydrocarbons, wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons is less than about 0.15, and wherein the ratio of ethene to ethane is greater than about 0.001.

20 1074. The method of claim 1058, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

1075. The method of claim 1058, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

25 1076. The method of claim 1058, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

30 1077. The method of claim 1058, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable

hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

1078. The method of claim 1058, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

1079. The method of claim 1058, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

1080. The method of claim 1058, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

15 1081. The method of claim 1058, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

20 1082. The method of claim 1058, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

25 1083. The method of claim 1058, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

30 1084. The method of claim 1058, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1085. The method of claim 1058, further comprising controlling the pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

5 1086. The method of claim 1058, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

10 1087. The method of claim 1086, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

15 1088. The method of claim 1058, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

1089. The method of claim 1058, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

20 1090. The method of claim 1058, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

25 1091. The method of claim 1058, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

1092. The method of claim 1058, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

1093. The method of claim 1058, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

5 1094. The method of claim 1058, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

10 1095. The method of claim 1058, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

15 1096. The method of claim 1058, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

20 1097. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;

allowing the heat to transfer from the one or more heat sources to a selected section of the formation; and

25 producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

30 1098. The method of claim 1097, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat

sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

1099. The method of claim 1097, wherein the one or more heat sources comprise
5 electrical heaters.

1100. The method of claim 1097, wherein the one or more heat sources comprise
surface burners.

10 1101. The method of claim 1097, wherein the one or more heat sources comprise
flameless distributed combustors.

15 1102. The method of claim 1097, wherein the one or more heat sources comprise natural
distributed combustors.

1103. The method of claim 1097, further comprising controlling a pressure and a
temperature within at least a majority of the selected section of the formation, wherein
the pressure is controlled as a function of temperature, or the temperature is controlled as
a function of pressure.

20 1104. The method of claim 1097, wherein controlling the temperature comprises
maintaining the temperature within the selected section within a pyrolysis temperature
range.

25 1105. The method of claim 1097, further comprising controlling the heat such that an
average heating rate of the selected section is less than about 1 °C per day during
pyrolysis.

30 1106. The method of claim 1097, wherein providing heat from the one or more heat
sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

5 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10
10 °C/day.

1107. The method of claim 1097, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

15 1108. The method of claim 1097, wherein providing heat from the one or more heat sources comprises heating the selected formation such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

20 1109. The method of claim 1097, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

1110. The method of claim 1097, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

25 1111. The method of claim 1097, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

30 1112. The method of claim 1097, wherein the produced mixture comprises non-condensable hydrocarbons, wherein a molar ratio of ethene to ethane in the non-

condensable hydrocarbons is less than about 0.15, and wherein the ratio of ethene to ethane is greater than about 0.001.

1113. The method of claim 1097, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

1114. The method of claim 1097, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

1115. The method of claim 1097, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

1116. The method of claim 1097, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

1117. The method of claim 1097, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

1118. The method of claim 1097, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

1119. The method of claim 1097, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

1120. The method of claim 1097, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5

1121. The method of claim 1097, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

10

1122. The method of claim 1097, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

15

1123. The method of claim 1097, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

20

1124. The method of claim 1097, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

25

1125. The method of claim 1097, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30

1126. The method of claim 1125, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

1127. The method of claim 1097, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1128. The method of claim 1097, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

5 1129. The method of claim 1097, further comprising:

providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

10 1130. The method of claim 1097, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

15 1131. The method of claim 1097, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

20 1132. The method of claim 1097, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

1133. The method of claim 1097, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

25 1134. The method of claim 1097, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

30 1135. The method of claim 1097, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat

sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

1136. The method of claim 1097, further comprising providing heat from three or more
5 heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

10 1137. A method of treating a hydrocarbon containing formation in situ, comprising:
heating a section of the formation to a pyrolysis temperature from at least a first
heat source, a second heat source and a third heat source, and wherein the first heat
source, the second heat source and the third heat source are located along a perimeter of
the section;

15 controlling heat input to the first heat source, the second heat source and the third heat source to limit a heating rate of the section to a rate configured to produce a mixture from the formation with an olefin content of less than about 15% by weight of condensable fluids (on a dry basis) within the produced mixture; and
producing the mixture from the formation through a production well.

20 1138. The method of claim 1137, wherein superposition of heat from the first heat source, second heat source, and third heat source pyrolyzes a portion of the hydrocarbons within the formation to fluids

25 1139. The method of claim 1137, wherein the pyrolysis temperature is between about 270 °C and about 400 °C.

1140. The method of claim 1137, wherein the first heat source is operated for less than about twenty four hours a day.

1141. The method of claim 1137, wherein the first heat source comprises an electrical heater.

5 1142. The method of claim 1137, wherein the first heat source comprises a surface burner.

10 1143. The method of claim 1137, wherein the first heat source comprises a flameless distributed combustor.

1144. The method of claim 1137, wherein the first heat source, second heat source and third heat source are positioned substantially at apexes of an equilateral triangle.

15 1145. The method of claim 1137, wherein the production well is located substantially at a geometrical center of the first heat source, second heat source, and third heat source.

1146. The method of claim 1137, further comprising a fourth heat source, fifth heat source, and sixth heat source located along the perimeter of the section.

20 1147. The method of claim 1146, wherein the heat sources are located substantially at apexes of a regular hexagon.

1148. The method of claim 1147, wherein the production well is located substantially at a center of the hexagon.

25 1149. The method of claim 1137, further comprising controlling a pressure and a temperature within at least a majority of the section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1150. The method of claim 1137, wherein controlling the temperature comprises maintaining the temperature within the selected section within a pyrolysis temperature range.

5 1151. The method of claim 1137, further comprising controlling the heat such that an average heating rate of the section is less than about 3 °C per day during pyrolysis.

1152. The method of claim 1137, further comprising controlling the heat such that an average heating rate of the section is less than about 1 °C per day during pyrolysis.

10

1153. The method of claim 1137, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

15 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

20 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

25

1154. The method of claim 1137, wherein heating the section of the formation comprises transferring heat substantially by conduction.

30

1155. The method of claim 1137, wherein providing heat from the one or more heat sources comprises heating the section such that a thermal conductivity of at least a portion of the section is greater than about 0.5 W/(m °C).

1156. The method of claim 1137, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

1157. The method of claim 1137, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

1158. The method of claim 1137, wherein the produced mixture comprises non-condensable hydrocarbons, wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons is less than about 0.15, and wherein the ratio of ethene to ethane is greater than about 0.001.

1159. The method of claim 1137, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

1160. The method of claim 1137, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

1161. The method of claim 1137, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

1162. The method of claim 1137, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

1163. The method of claim 1137, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

5 1164. The method of claim 1137, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

10 1165. The method of claim 1137, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

15 1166. The method of claim 1137, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

20 1167. The method of claim 1137, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

25 1168. The method of claim 1137, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1169. The method of claim 1137, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

30 1170. The method of claim 1137, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

1171. The method of claim 1137, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

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1172. The method of claim 1171, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

10 1173. The method of claim 1137, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

15 1174. The method of claim 1137, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

1175. The method of claim 1137, further comprising:

providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

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1176. The method of claim 1137, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

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1177. The method of claim 1137, heating the section comprises increasing a permeability of a majority of the section to greater than about 100 millidarcy.

1178. The method of claim 1137, wherein heating the section comprises substantially uniformly increasing a permeability of a majority of the section.

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1179. The method of claim 1137, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

5 1180. The method of claim 1137, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

10 1181. The method of claim 1137, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

15 1182. The method of claim 1137, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

20 1183. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation; and
25 producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

30 1184. The method of claim 1183, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat

sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

1185. The method of claim 1183, wherein the one or more heat sources comprise
5 electrical heaters.

1186. The method of claim 1183, wherein the one or more heat sources comprise
surface burners.

10 1187. The method of claim 1183, wherein the one or more heat sources comprise
flameless distributed combustors.

15 1188. The method of claim 1183, wherein the one or more heat sources comprise natural
distributed combustors.

1189. The method of claim 1183, further comprising controlling a pressure and a
temperature within at least a majority of the selected section of the formation, wherein
the pressure is controlled as a function of temperature, or the temperature is controlled as
a function of pressure.

20 1190. The method of claim 1189, wherein controlling the temperature comprises
maintaining the temperature within the selected section within a pyrolysis temperature
range.

25 1191. The method of claim 1183, further comprising controlling the heat such that an
average heating rate of the selected section is less than about 1 °C per day during
pyrolysis.

1192. The method of claim 1183, wherein providing heat from the one or more heat
sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

5 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h*V*C_v*\rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 10 $^{\circ}\text{C}/\text{day}$.

1193. The method of claim 1183, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

15 1194. The method of claim 1183, wherein providing heat from the one or more heat sources comprises heating the selected formation such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 $\text{W}/(\text{m } ^{\circ}\text{C})$.

20 1195. The method of claim 1183, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25 $^{\circ}$.

1196. The method of claim 1183, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

25 1197. The method of claim 1183, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

30 1198. The method of claim 1183, wherein the produced mixture comprises non-condensable hydrocarbons, wherein a molar ratio of ethene to ethane in the non-

condensable hydrocarbons is less than about 0.15, and wherein the ratio of ethene to ethane is greater than about 0.001.

1199. The method of claim 1183, wherein the produced mixture comprises condensable 5 hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

1200. The method of claim 1183, wherein the produced mixture comprises condensable 10 hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

1201. The method of claim 1183, wherein the produced mixture comprises condensable 15 hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

1202. The method of claim 1183, wherein the produced mixture comprises condensable 20 hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

1203. The method of claim 1183, wherein the produced mixture comprises condensable 25 hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

1204. The method of claim 1183, wherein the produced mixture comprises condensable 30 hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

1205. The method of claim 1183, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the 30 condensable hydrocarbons are cycloalkanes.

1206. The method of claim 1183, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

1207. The method of claim 1183, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1208. The method of claim 1183, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1209. The method of claim 1183, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

1210. The method of claim 1183, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

1211. The method of claim 1211, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

1212. The method of claim 1183, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1213. The method of claim 1183, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

1214. The method of claim 1183, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons
within the section; and
heating a portion of the section with heat from hydrogenation.

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1215. The method of claim 1183, wherein the produced mixture comprises hydrogen
and condensable hydrocarbons, the method further comprising hydrogenating a portion of
the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

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1216. The method of claim 1183, wherein allowing the heat to transfer comprises
increasing a permeability of a majority of the selected section to greater than about 100
millidarcy.

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1217. The method of claim 1183, wherein allowing the heat to transfer comprises
substantially uniformly increasing a permeability of a majority of the selected section.

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1218. The method of claim 1183, further comprising controlling the heat to yield greater
than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer
Assay.

1219. The method of claim 1183, wherein producing the mixture comprises producing
the mixture in a production well, and wherein at least about 7 heat sources are disposed in
the formation for each production well.

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1220. The method of claim 1183, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat
sources are located in the formation in a unit of heat sources, and wherein the unit of heat
sources comprises a triangular pattern.

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1221. The method of claim 1183, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat

sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

5 1222. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the
formation;
allowing the heat to transfer from the one or more heat sources to a selected
section of the formation; and
10 producing a mixture from the formation, wherein the produced mixture comprises
condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated
on an atomic basis, of the condensable hydrocarbons is oxygen.

15 1223. The method of claim 1222, wherein the one or more heat sources comprise at
least two heat sources, and wherein superposition of heat from at least the two heat
sources pyrolyzes at least some hydrocarbons within the selected section of the
formation.

20 1224. The method of claim 1222, wherein the one or more heat sources comprise
electrical heaters.

1225. The method of claim 1222, wherein the one or more heat sources comprise
surface burners.

25 1226. The method of claim 1222, wherein the one or more heat sources comprise
flameless distributed combustors.

1227. The method of claim 1222, wherein the one or more heat sources comprise natural
distributed combustors.

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1228. The method of claim 1222, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

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1229. The method of claim 1228, wherein controlling the temperature comprises maintaining the temperature within the selected section within a pyrolysis temperature range.

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1230. The method of claim 1222, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

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1231. The method of claim 1222, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

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wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

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1232. The method of claim 1222, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

1233. The method of claim 1222, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

5 1234. The method of claim 1222, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

10 1235. The method of claim 1222, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

15 1236. The method of claim 1222, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

20 1237. The method of claim 1222, wherein the produced mixture comprises non-condensable hydrocarbons, wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons is less than about 0.15, and wherein the ratio of ethene to ethane is greater than about 0.001.

25 1238. The method of claim 1222, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

30 1239. The method of claim 1222, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

1240. The method of claim 1222, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

1241. The method of claim 1222, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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1242. The method of claim 1222, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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1243. The method of claim 1222, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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1244. The method of claim 1222, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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1245. The method of claim 1222, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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1246. The method of claim 1222, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

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1247. The method of claim 1222, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1248. The method of claim 1222, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1249. The method of claim 1222, further comprising controlling a pressure within at 5 least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

1250. The method of claim 1222, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ 10 within the mixture is greater than about 0.5 bar.

1251. The method of claim 1250, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

1252. The method of claim 1222, further comprising altering a pressure within the 15 formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1253. The method of claim 1222, wherein controlling formation conditions comprises 20 recirculating a portion of hydrogen from the mixture into the formation.

1254. The method of claim 1222, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons
within the section; and
heating a portion of the section with heat from hydrogenation.

1255. The method of claim 1222, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

1256. The method of claim 1222, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

5 1257. The method of claim 1222, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

10 1258. The method of claim 1222, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

15 1259. The method of claim 1222, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 1260. The method of claim 1222, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 1261. The method of claim 1222, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30 1262. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation; and

producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5 1263. The method of claim 1262, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

10 1264. The method of claim 1262, wherein the one or more heat sources comprise electrical heaters.

15 1265. The method of claim 1262, wherein the one or more heat sources comprise surface burners.

20 1266. The method of claim 1262, wherein the one or more heat sources comprise flameless distributed combustors.

25 1267. The method of claim 1262, wherein the one or more heat sources comprise natural distributed combustors.

1268. The method of claim 1262, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

30 1269. The method of claim 1268, wherein controlling the temperature comprises maintaining the temperature within the selected section within a pyrolysis temperature range.

1270. The method of claim 1262, further comprising controlling the heat into such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

5 1271. The method of claim 1262, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

10 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

15 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

20 1272. The method of claim 1262, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

25 1273. The method of claim 1262, wherein providing heat from the one or more heat sources comprises heating the selected formation such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

1274. The method of claim 1262, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

30 1275. The method of claim 1262, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

1276. The method of claim 1262, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

5 1277. The method of claim 1262, wherein the produced mixture comprises non-condensable hydrocarbons, wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons is less than about 0.15, and wherein the ratio of ethene to ethane is greater than about 0.001.

10 1278. The method of claim 1262, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

15 1279. The method of claim 1262, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

20 1280. The method of claim 1262, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

25 1281. The method of claim 1262, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

1282. The method of claim 1262, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

1283. The method of claim 1262, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5 1284. The method of claim 1262, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

10 1285. The method of claim 1262, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

15 1286. The method of claim 1262, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

20 1287. The method of claim 1262, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

25 1288. The method of claim 1262, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

30 1289. The method of claim 1262, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

1290. The method of claim 1289, wherein the partial pressure of H₂ is measured when the mixture is at a production well.

1291. The method of claim 1262, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5 1292. The method of claim 1262, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

1293. The method of claim 1262, further comprising:

10 providing hydrogen (H_2) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

15 1294. The method of claim 1262, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, the method further comprising hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

20 1295. The method of claim 1262, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

1296. The method of claim 1262, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

25 1297. The method of claim 1262, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

30 1298. The method of claim 1262, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

1299. The method of claim 1262, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

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1300. The method of claim 1262, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

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1301. A method of treating a hydrocarbon containing formation in situ, comprising:
raising a temperature of a first section of the formation with one or more heat sources to a first pyrolysis temperature;

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heating the first section to an upper pyrolysis temperature, wherein heat is supplied to the first section at a rate configured to inhibit olefin production;
producing a first mixture from the formation, wherein the first mixture comprises condensable hydrocarbons and H₂;

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creating a second mixture from the first mixture, wherein the second mixture comprises a higher concentration of H₂ than the first mixture;

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raising a temperature of a second section of the formation with one or more heat sources to a second pyrolysis temperature;
providing a portion of the second mixture to the second section;
heating the second section to an upper pyrolysis temperature, wherein heat is supplied to the second section at a rate configured to inhibit olefin production; and
producing a third mixture from the second section.

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1302. The method of claim 1301, wherein creating the second mixture comprises removing condensable hydrocarbons from the first mixture.

1303. The method of claim 1301, wherein creating the second mixture comprises
removing water from the first mixture.

1304. The method of claim 1301, wherein creating the second mixture comprises
5 removing carbon dioxide from the first mixture.

1305. The method of claim 1301, wherein the first pyrolysis temperature is greater than
about 270 °C.

10 1306. The method of claim 1301, wherein the second pyrolysis temperature is greater
than about 270 °C.

15 1307. The method of claim 1301, wherein the upper pyrolysis temperature is about 500
°C.

1308. The method of claim 1301, wherein the one or more heat sources comprise at
least two heat sources, and wherein superposition of heat from at least the two heat
sources pyrolyzes at least some hydrocarbons within the first or second selected section
of the formation.

20 1309. The method of claim 1301, wherein the one or more heat sources comprise
electrical heaters.

25 1310. The method of claim 1301, wherein the one or more heat sources comprise
surface burners.

1311. The method of claim 1301, wherein the one or more heat sources comprise
flameless distributed combustors.

30 1312. The method of claim 1301, wherein the one or more heat sources comprise natural
distributed combustors.

1313. The method of claim 1301, further comprising controlling a pressure and a
temperature within at least a majority of the first section and the second section of the
formation, wherein the pressure is controlled as a function of temperature, or the
temperature is controlled as a function of pressure.

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1314. The method of claim 1301, further comprising controlling the heat to the first and
second sections such that an average heating rate of the first and second sections is less
than about 1 °C per day during pyrolysis.

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1315. The method of claim 1301, wherein heating the first and the second sections
comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the
one or more heat sources, wherein the formation has an average heat capacity (C_v), and
wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of
the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr ,
wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the
formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10
°C/day.

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1316. The method of claim 1301, wherein heating the first and second sections
comprises transferring heat substantially by conduction.

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1317. The method of claim 1301, wherein heating the first and second sections
comprises heating the first and second sections such that a thermal conductivity of at least
a portion of the first and second sections is greater than about 0.5 W/(m °C).

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1318. The method of claim 1301, wherein the first or third mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

1319. The method of claim 1301, wherein the first or third mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

1320. The method of claim 1301, wherein the first or third mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

1321. The method of claim 1301, wherein the first or third mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

1322. The method of claim 1301, wherein the first or third mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

1323. The method of claim 1301, wherein the first or third mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

1324. The method of claim 1301, wherein the first or third mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

1325. The method of claim 1301, wherein the first or third mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

1326. The method of claim 1301, wherein the first or third mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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1327. The method of claim 1301, wherein the first or third mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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1328. The method of claim 1301, wherein the first or third mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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1329. The method of claim 1301, wherein the first or third mixture comprises a non-condensable component, and wherein the non-condensable component comprises hydrogen, and wherein the hydrogen is greater than about 10 % by volume of the non-condensable component and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

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1330. The method of claim 1301, wherein the first or third mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1331. The method of claim 1301, wherein the first or third mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

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1332. The method of claim 1301, further comprising controlling a pressure within at least a majority of the first or second sections of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

1333. The method of claim 1301, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

5 1334. The method of claim 1333, wherein the partial pressure of H₂ within a mixture is measured when the mixture is at a production well.

10 1335. The method of claim 1301, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1336. The method of claim 1301, further comprising:
providing hydrogen (H₂) to the first or second section to hydrogenate hydrocarbons within the first or second section; and
heating a portion of the first or second section with heat from hydrogenation.

15 1337. The method of claim 1301, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

20 1338. The method of claim 1301, further comprising increasing a permeability of a majority of the first or second section to greater than about 100 millidarcy.

25 1339. The method of claim 1301, further comprising substantially uniformly increasing a permeability of a majority of the first or second section.

1340. The method of claim 1301, wherein the heating is controlled to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

1341. The method of claim 1301, wherein producing the first or third mixture comprises producing the first or third mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

5 1342. The method of claim 1301, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

10 1343. The method of claim 1301, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

15 1344. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation;
20 producing a mixture from the formation; and
hydrogenating a portion of the produced mixture with H₂ produced from the formation.

25 1345. The method of claim 1344, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

30 1346. The method of claim 1344, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

1347. The method of claim 1344, wherein the one or more heat sources comprise
electrical heaters.

5 1348. The method of claim 1344, wherein the one or more heat sources comprise
surface burners.

10 1349. The method of claim 1344, wherein the one or more heat sources comprise
flameless distributed combustors.

1350. The method of claim 1344, wherein the one or more heat sources comprise natural
distributed combustors.

15 1351. The method of claim 1344, further comprising controlling a pressure and a
temperature within at least a majority of the selected section of the formation, wherein
the pressure is controlled as a function of temperature, or the temperature is controlled as
a function of pressure.

20 1352. The method of claim 1344, further comprising controlling the heat such that an
average heating rate of the selected section is less than about 1 °C per day during
pyrolysis.

1353. The method of claim 1344, wherein providing heat from the one or more heat
sources to at least the portion of formation comprises:
25 heating a selected volume (V) of the hydrocarbon containing formation from the
one or more heat sources, wherein the formation has an average heat capacity (C_v), and
wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of
the formation; and
30 wherein heating energy/day provided to the volume is equal to or less than P_{wr} ,
wherein P_{wr} is calculated by the equation:

$$P_{wr} = h * V * C_v * \rho_B$$

wherein P_{wr} is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

5 1354. The method of claim 1344, wherein allowing the heat to transfer comprises
transferring heat substantially by conduction.

10 1355. The method of claim 1344, wherein providing heat from the one or more heat
sources comprises heating the selected section such that a thermal conductivity of at least
a portion of the selected section is greater than about 0.5 W/(m °C).

15 1356. The method of claim 1344, wherein the produced mixture comprises condensable
hydrocarbons having an API gravity of at least about 25°.

20 1357. The method of claim 1344, wherein the produced mixture comprises condensable
hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the
condensable hydrocarbons are olefins.

25 1358. The method of claim 1344, wherein the produced mixture comprises non-
condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-
condensable hydrocarbons ranges from about 0.001 to about 0.15.

1359. The method of claim 1344, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is nitrogen.

30 1360. The method of claim 1344, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is oxygen.

1361. The method of claim 1344, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5 1362. The method of claim 1344, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

10 1363. The method of claim 1344, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

15 1364. The method of claim 1344, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

20 1365. The method of claim 1344, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

25 1366. The method of claim 1344, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 1367. The method of claim 1344, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

1368. The method of claim 1344, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1369. The method of claim 1344, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1370. The method of claim 1344, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

1371. The method of claim 1344, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

1372. The method of claim 1344, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

1373. The method of claim 1344, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1374. The method of claim 1344, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

1375. The method of claim 1344, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

1376. The method of claim 1344, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

1377. The method of claim 1344, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

1378. The method of claim 1344, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

1379. The method of claim 1344, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

1380. The method of claim 1344, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

1381. A method of treating a hydrocarbon containing formation in situ, comprising:
heating a first section of the formation;
producing H₂ from the first section of formation;
heating a second section of the formation; and
recirculating a portion of the H₂ from the first section into the second section of the formation to provide a reducing environment within the second section of the formation.

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1382. The method of claim 1381, wherein heating the first section or heating the second section comprises heating with an electrical heater.

5 1383. The method of claim 1381, wherein heating the first section or heating the second section comprises heating with a surface burner.

1384. The method of claim 1381, wherein heating the first section or heating the second section comprises heating with a flameless distributed combustor.

10 1385. The method of claim 1381, wherein heating the first section or heating the second section comprises heating with a natural distributed combustor.

15 1386. The method of claim 1381, further comprising controlling a pressure and a temperature within at least a majority of the first or second section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

20 1387. The method of claim 1381, further comprising controlling the heat such that an average heating rate of the first or second section is less than about 1 °C per day during pyrolysis.

1388. The method of claim 1381, wherein heating the first section or heating the second section further comprises:

25 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

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$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

5 1389. The method of claim 1381, wherein heating the first section or heating the second section comprises transferring heat substantially by conduction.

10 1390. The method of claim 1381, wherein heating the first section or heating the second section comprises heating the formation such that a thermal conductivity of at least a portion of the first or second section is greater than about 0.5 W/(m °C).

15 1391. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

20 1392. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

25 1393. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

30 1394. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

1395. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

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1396. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

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1397. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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1398. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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1399. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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1400. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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1401. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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1402. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the 10 hydrogen is less than about 80 % by volume of the non-condensable component.

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1403. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

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1404. The method of claim 1381, further comprising producing a mixture from the second section, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

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1405. The method of claim 1381, further comprising controlling a pressure within at least a majority of the first or second section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

25

1406. The method of claim 1381, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

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1407. The method of claim 1406, wherein the partial pressure of H₂ within a mixture is measured when the mixture is at a production well.

1408. The method of claim 1381, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5 1409. The method of claim 1381, further comprising:
providing hydrogen (H₂) to the second section to hydrogenate hydrocarbons within the section; and
heating a portion of the second section with heat from hydrogenation.

10 1410. The method of claim 1381, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

15 1411. The method of claim 1381, wherein heating the first section or heating the second section comprises increasing a permeability of a majority of the first or second section, respectively, to greater than about 100 millidarcy.

20 1412. The method of claim 1381, wherein heating the first section or heating the second section comprises substantially uniformly increasing a permeability of a majority of the first or second section, respectively.

25 1413. The method of claim 1381, further comprises controlling the heating of the first section or controlling the heat of the second section to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

1414. The method of claim 1381, further comprising producing a mixture from the formation in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

1415. The method of claim 1381, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

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1416. The method of claim 1381, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

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1417. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;

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allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

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producing a mixture from the formation; and

controlling formation conditions such that the mixture produced from the formation comprises condensable hydrocarbons including H₂, wherein the partial pressure of H₂ within the mixture is greater than about 0.5 bar.

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1418. The method of claim 1417, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

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1419. The method of claim 1417, wherein controlling formation conditions comprises maintaining a temperature within the selected section within a pyrolysis temperature range.

1420. The method of claim 1417, wherein the one or more heat sources comprise electrical heaters.

5 1421. The method of claim 1417, wherein the one or more heat sources comprise surface burners.

1422. The method of claim 1417, wherein the one or more heat sources comprise flameless distributed combustors.

10 1423. The method of claim 1417, wherein the one or more heat sources comprise natural distributed combustors.

15 1424. The method of claim 1417, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

20 1425. The method of claim 1417, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

1426. The method of claim 1417, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

25 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than P_{wr} , wherein P_{wr} is calculated by the equation:

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$$P_{wr} = h * V * C_v * \rho_B$$

wherein P_{wr} is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

5 1427. The method of claim 1417, wherein allowing the heat to transfer comprises
transferring heat substantially by conduction.

10 1428. The method of claim 1417, wherein providing heat from the one or more heat
sources comprises heating the selected section such that a thermal conductivity of at least
a portion of the selected section is greater than about 0.5 W/(m °C).

15 1429. The method of claim 1417, wherein the produced mixture comprises condensable
hydrocarbons having an API gravity of at least about 25°.

20 1430. The method of claim 1417, wherein the produced mixture comprises condensable
hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the
condensable hydrocarbons are olefins.

25 1431. The method of claim 1417, wherein the produced mixture comprises non-
condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-
condensable hydrocarbons ranges from about 0.001 to about 0.15.

1432. The method of claim 1417, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is nitrogen.

30 1433. The method of claim 1417, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is oxygen.

1434. The method of claim 1417, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5 1435. The method of claim 1417, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

10 1436. The method of claim 1417, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

15 1437. The method of claim 1417, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

20 1438. The method of claim 1417, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

25 1439. The method of claim 1417, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 1440. The method of claim 1417, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

1441. The method of claim 1417, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5 1442. The method of claim 1417, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

10 1443. The method of claim 1417, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

1444. The method of claim 1417, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

15 1445. The method of claim 1417, wherein controlling formation conditions comprises recirculating a portion of hydrogen from the mixture into the formation.

20 1446. The method of claim 1417, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

25 1447. The method of claim 1417, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

30 1448. The method of claim 1417, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

1449. The method of claim 1417, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

1450. The method of claim 1417, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

1451. The method of claim 1417, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

1452. The method of claim 1417, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

1453. The method of claim 1417, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

1454. The method of claim 1417, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

1455. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

maintaining a pressure of the selected section above atmospheric pressure to increase a partial pressure of H₂, as compared to the partial pressure of H₂ at atmospheric pressure, in at least a majority of the selected section; and

producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

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1456. The method of claim 1455, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

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1457. The method of claim 1455, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

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1458. The method of claim 1455, wherein the one or more heat sources comprise electrical heaters.

1459. The method of claim 1455, wherein the one or more heat sources comprise surface burners.

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1460. The method of claim 1455, wherein the one or more heat sources comprise flameless distributed combustors.

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1461. The method of claim 1455, wherein the one or more heat sources comprise natural distributed combustors.

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1462. The method of claim 1455, further comprising controlling the pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1463. The method of claim 1455, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

5 1464. The method of claim 1455, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

10 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

15 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

20 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

25 1465. The method of claim 1455, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

30 1466. The method of claim 1455, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

1467. The method of claim 1455, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

1468. The method of claim 1455, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

1469. The method of claim 1455, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

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1470. The method of claim 1455, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

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1471. The method of claim 1455, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

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1472. The method of claim 1455, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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1473. The method of claim 1455, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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1474. The method of claim 1455, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

1475. The method of claim 1455, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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1476. The method of claim 1455, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5 1477. The method of claim 1455, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

10 1478. The method of claim 1455, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

15 1479. The method of claim 1455, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1480. The method of claim 1455, further comprising controlling the pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

20 1481. The method of claim 1455, further comprising increasing the pressure of the selected section, to an upper limit of about 21 bar absolute, to increase an amount of non-condensable hydrocarbons produced from the formation.

25 1482. The method of claim 1455, further comprising decreasing pressure of the selected section, to a lower limit of about atmospheric pressure, to increase an amount of condensable hydrocarbons produced from the formation.

30 1483. The method of claim 1455, wherein the partial pressure comprises a partial pressure based on properties measured at a production well.

1484. The method of claim 1455, further comprising altering the pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5 1485. The method of claim 1455, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

1486. The method of claim 1455, further comprising:

10 providing hydrogen (H_2) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

1487. The method of claim 1455, further comprising:

15 producing hydrogen and condensable hydrocarbons from the formation; and hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

1488. The method of claim 1455, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

20 1489. The method of claim 1455, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

25 1490. The method of claim 1455, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

30 1491. The method of claim 1455, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

1492. The method of claim 1455, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat
sources are located in the formation in a unit of heat sources, and wherein the unit of heat
sources comprises a triangular pattern.

5

1493. The method of claim 1455, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat
sources are located in the formation in a unit of heat sources, wherein the unit of heat
sources comprises a triangular pattern, and wherein a plurality of the units are repeated
10 over an area of the formation to form a repetitive pattern of units.

10

1494. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the
formation;
15 allowing the heat to transfer from the one or more heat sources to a selected
section of the formation;
providing H₂ to the formation to produce a reducing environment in at least some
of the formation;
20 producing a mixture from the formation.

20

1495. The method of claim 1494, wherein the one or more heat sources comprise at
least two heat sources, and wherein superposition of heat from at least the two heat
sources pyrolyzes at least some hydrocarbons within the selected section of the
formation.

25

1496. The method of claim 1494, further comprising maintaining a temperature within
the selected section within a pyrolysis temperature range.

30

1497. The method of claim 1494, further comprising separating a portion of hydrogen
within the mixture and recirculating the portion into the formation.

1498. The method of claim 1494, wherein the one or more heat sources comprise electrical heaters.

5 1499. The method of claim 1494, wherein the one or more heat sources comprise surface burners.

1500. The method of claim 1494, wherein the one or more heat sources comprise flameless distributed combustors.

10 1501. The method of claim 1494, wherein the one or more heat sources comprise natural distributed combustors.

15 1502. The method of claim 1494, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

20 1503. The method of claim 1494, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

25 1504. The method of claim 1494, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

30 wherein heating energy/day provided to the volume is equal to or less than P_{wr} , wherein P_{wr} is calculated by the equation:

$$P_{wr} = h * V * C_v * \rho_B$$

wherein P_{wr} is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

5 1505. The method of claim 1494, wherein allowing the heat to transfer comprises
transferring heat substantially by conduction.

10 1506. The method of claim 1494, wherein providing heat from the one or more heat
sources comprises heating the selected section such that a thermal conductivity of at least
a portion of the selected section is greater than about 0.5 W/(m °C).

1507. The method of claim 1494, wherein the produced mixture comprises condensable
hydrocarbons having an API gravity of at least about 25°.

15 1508. The method of claim 1494, wherein the produced mixture comprises condensable
hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the
condensable hydrocarbons are olefins.

20 1509. The method of claim 1494, wherein the produced mixture comprises non-
condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-
condensable hydrocarbons ranges from about 0.001 to about 0.15.

25 1510. The method of claim 1494, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is nitrogen.

1511. The method of claim 1494, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is oxygen.

1512. The method of claim 1494, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5 1513. The method of claim 1494, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

10 1514. The method of claim 1494, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

15 1515. The method of claim 1494, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

20 1516. The method of claim 1494, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

25 1517. The method of claim 1494, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 1518. The method of claim 1494, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

1519. The method of claim 1494, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1520. The method of claim 1494, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1521. The method of claim 1494, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

10 1522. The method of claim 1494, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

15 1523. The method of claim 1494, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

20 1524. The method of claim 1494, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1525. The method of claim 1494, wherein providing hydrogen (H₂) to the formation further comprises:

25 hydrogenating hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

1526. The method of claim 1494, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

1527. The method of claim 1494, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

5 1528. The method of claim 1494, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

10 1529. The method of claim 1494, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

15 1530. The method of claim 1494, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 1531. The method of claim 1494, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 1532. The method of claim 1494, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30 1533. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

providing H₂ to the selected section to hydrogenate hydrocarbons within the selected section and to heat a portion of the section with heat from the hydrogenation; and

5 controlling heating of the selected section by controlling amounts of H₂ provided to the selected section.

10 1534. The method of claim 1533, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

15 1535. The method of claim 1533, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

20 1536. The method of claim 1533, wherein the one or more heat sources comprise electrical heaters.

25 1537. The method of claim 1533, wherein the one or more heat sources comprise surface burners.

30 1538. The method of claim 1533, wherein the one or more heat sources comprise flameless distributed combustors.

1539. The method of claim 1533, wherein the one or more heat sources comprise natural distributed combustors.

1540. The method of claim 1533, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1541. The method of claim 1533, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

5 1542. The method of claim 1533, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

10 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

15 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

20 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

1543. The method of claim 1533, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

25 1544. The method of claim 1533, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

1545. The method of claim 1533, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

30 1546. The method of claim 1533, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and

wherein about 0.1 % by weight to about 15% by weight of the condensable hydrocarbons are olefins.

1547. The method of claim 1533, further comprising producing a mixture from the
5 formation, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

1548. The method of claim 1533, further comprising producing a mixture from the
10 formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

1549. The method of claim 1533, further comprising producing a mixture from the
15 formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1% by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

1550. The method of claim 1533, further comprising producing a mixture from the
20 formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

1551. The method of claim 1533, further comprising producing a mixture from the
25 formation, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

1552. The method of claim 1533, further comprising producing a mixture from the
30 formation, wherein the produced mixture comprises condensable hydrocarbons, and

wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

1553. The method of claim 1533, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

1554. The method of claim 1533, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

1555. The method of claim 1533, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

1556. The method of claim 1533, further comprising producing a mixture from the formation, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

1557. The method of claim 1533, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1558. The method of claim 1533, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1559. The method of claim 1533, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

5

1560. The method of claim 1533, further comprising controlling formation conditions to produce a mixture from the formation, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

10 1561. The method of claim 1560, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

15 1562. The method of claim 1533, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1563. The method of claim 1533, further comprising controlling formation conditions by recirculating a portion of hydrogen from a produced mixture into the formation.

20 1564. The method of claim 1533, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

25 1565. The method of claim 1533, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

30 1566. The method of claim 1533, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

1567. The method of claim 1533, wherein the heating is controlled of claim 1533, further comprising producing a mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

5 1568. The method of claim 1533, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

10 1569. The method of claim 1533, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

15 1570. An in situ method for producing H₂ from a hydrocarbon containing formation, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation; and
producing a mixture from the formation, wherein a H₂ partial pressure within the mixture is greater than about 0.5 bar.

20 1571. The method of claim 1570, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

25 1572. The method of claim 1570, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

1573. The method of claim 1570, wherein the one or more heat sources comprise electrical heaters.

5 1574. The method of claim 1570, wherein the one or more heat sources comprise surface burners.

1575. The method of claim 1570, wherein the one or more heat sources comprise flameless distributed combustors.

10 1576. The method of claim 1570, wherein the one or more heat sources comprise natural distributed combustors.

15 1577. The method of claim 1570, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

20 1578. The method of claim 1570, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

1579. The method of claim 1570, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

25 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

30 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

5 1580. The method of claim 1570, wherein allowing the heat to transfer comprises
transferring heat substantially by conduction.

10 1581. The method of claim 1570, wherein providing heat from the one or more heat
sources comprises heating the selected section such that a thermal conductivity of at least
a portion of the selected section is greater than about 0.5 W/(m °C).

15 1582. The method of claim 1570, wherein the produced mixture comprises condensable
hydrocarbons having an API gravity of at least about 25°.

20 1583. The method of claim 1570, wherein the produced mixture comprises condensable
hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the
condensable hydrocarbons are olefins.

25 1584. The method of claim 1570, wherein the produced mixture comprises non-
condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-
condensable hydrocarbons ranges from about 0.001 to about 0.15.

1585. The method of claim 1570, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is nitrogen.

1586. The method of claim 1570, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is oxygen.

1587. The method of claim 1570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5 1588. The method of claim 1570, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

10 1589. The method of claim 1570, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

15 1590. The method of claim 1570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

20 1591. The method of claim 1570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

25 1592. The method of claim 1570, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 1593. The method of claim 1570, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

1594. The method of claim 1570, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5 1595. The method of claim 1570, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

10 1596. The method of claim 1570, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

15 1597. The method of claim 1570, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1598. The method of claim 1570, further comprising recirculating a portion of the hydrogen within the mixture into the formation.

20 1599. The method of claim 1570, further comprising condensing a hydrocarbon component from the produced mixture and hydrogenating the condensed hydrocarbons with a portion of the hydrogen.

1600. The method of claim 1570, further comprising:

25 providing hydrogen (H_2) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

1601. The method of claim 1570, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

1602. The method of claim 1570, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

1603. The method of claim 1570, further comprising controlling the heat to yield greater
5 than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

1604. The method of claim 1570, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in
10 the formation for each production well.

1605. The method of claim 1570, further comprising providing heat from three or more
15 heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

1606. The method of claim 1570, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated
20 over an area of the formation to form a repetitive pattern of units.

1607. The method of claim 1570, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

25
1608. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected
30 section of the formation;

wherein the selected section has been selected for heating using an atomic hydrogen weight percentage of at least a portion of hydrocarbons in the selected section, and wherein at least the portion of the hydrocarbons in the selected section comprises an atomic hydrogen weight percentage, when measured on a dry, ash-free basis, of greater than about 4.0 %; and

5 producing a mixture from the formation.

1609. The method of claim 1608, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat
10 sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

1610. The method of claim 1608, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

15 1611. The method of claim 1608, wherein the one or more heat sources comprise electrical heaters.

20 1612. The method of claim 1608, wherein the one or more heat sources comprise surface burners.

1613. The method of claim 1608, wherein the one or more heat sources comprise flameless distributed combustors.

25 1614. The method of claim 1608, wherein the one or more heat sources comprise natural distributed combustors.

1615. The method of claim 1608, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1616. The method of claim 1608, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

5

1617. The method of claim 1608, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

10 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

15 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

15 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

20 1618. The method of claim 1608, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

25

1619. The method of claim 1608, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

25

1620. The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

30

1621. The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

1622. The method of claim 1608, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5

1623. The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

10 1624. The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

15 1625. The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

20 1626. The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

25 1627. The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

30 1628. The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

1629. The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5 1630. The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

10 1631. The method of claim 1608, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

15 1632. The method of claim 1608, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

20 1633. The method of claim 1608, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1634. The method of claim 1608, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

25 1635. The method of claim 1608, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 1636. The method of claim 1635, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

1637. The method of claim 1608, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5 1638. The method of claim 1608, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

10 1639. The method of claim 1608, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

15 1640. The method of claim 1608, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

20 1641. The method of claim 1608, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

1642. The method of claim 1608, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

25 1643. The method of claim 1608, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

30 1644. The method of claim 1608, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

1645. The method of claim 1608, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat
sources are located in the formation in a unit of heat sources, and wherein the unit of heat
sources comprises a triangular pattern.

1646. The method of claim 1608, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat
sources are located in the formation in a unit of heat sources, wherein the unit of heat
sources comprises a triangular pattern, and wherein a plurality of the units are repeated
over an area of the formation to form a repetitive pattern of units.

1647. A method of treating a hydrocarbon containing formation in situ, comprising:
15 providing heat from one or more heat sources to at least a portion of the
formation;
allowing the heat to transfer from the one or more heat sources to a selected
section of the formation;
wherein at least some hydrocarbons within the selected section have an initial
atomic hydrogen weight percentage of greater than about 4.0 %; and
20 producing a mixture from the formation.

1648. The method of claim 1647, wherein the one or more heat sources comprise at
least two heat sources, and wherein superposition of heat from at least the two heat
sources pyrolyzes at least some hydrocarbons within the selected section of the
formation.

1649. The method of claim 1647, further comprising maintaining a temperature within
the selected section within a pyrolysis temperature range.

30 1650. The method of claim 1647, wherein the one or more heat sources comprise
electrical heaters.

1651. The method of claim 1647, wherein the one or more heat sources comprise surface burners.

5 1652. The method of claim 1647, wherein the one or more heat sources comprise flameless distributed combustors.

1653. The method of claim 1647, wherein the one or more heat sources comprise natural distributed combustors.

10 1654. The method of claim 1647, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

15 1655. The method of claim 1647, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

20 1656. The method of claim 1647, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:
heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

25 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

1657. The method of claim 1647, whercin allowing the heat to transfer comprises transferring heat substantially by conduction.

1658. The method of claim 1647, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least 5 a portion of the selected section is greater than about 0.5 W/(m °C).

1659. The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

10 1660. The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

15 1661. The method of claim 1647, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

20 1662. The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

25 1663. The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

1664. The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

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1665. The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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1666. The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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1667. The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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1668. The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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1669. The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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1670. The method of claim 1647, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

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1671. The method of claim 1647, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1672. The method of claim 1647, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1673. The method of claim 1647, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

1674. The method of claim 1647, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

1675. The method of claim 1674, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

1676. The method of claim 1647, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1677. The method of claim 1647, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

1678. The method of claim 1647, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

1679. The method of claim 1647, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

1680. The method of claim 1647, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

5 1681. The method of claim 1647, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

10 1682. The method of claim 1647, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

15 1683. The method of claim 1647, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 1684. The method of claim 1647, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 1685. The method of claim 1647, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

1686. A method of treating a hydrocarbon containing formation in situ, comprising:
30 providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

wherein the selected section has been selected for heating using vitrinite reflectance of at least some hydrocarbons in the selected section, and wherein at least a portion of the hydrocarbons in the selected section comprises a vitrinite reflectance of greater than about 0.3 %;

5 wherein at least a portion of the hydrocarbons in the selected section comprises a vitrinite reflectance of less than about 4.5 %; and
producing a mixture from the formation.

1687. The method of claim 1686, wherein the one or more heat sources comprise at
10 least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

1688. The method of claim 1686, further comprising maintaining a temperature within
15 the selected section within a pyrolysis temperature.

1689. The method of claim 1686, wherein the vitrinite reflectance of at least the portion
of hydrocarbons within the selected section is between about 0.47 % and about 1.5 %
such that a majority of the produced mixture comprises condensable hydrocarbons.

20 1690. The method of claim 1686, wherein the vitrinite reflectance of at least the portion
of hydrocarbons within the selected section is between about 1.4 % and about 4.2 % such
that a majority of the produced mixture comprises non-condensable hydrocarbons.

25 1691. The method of claim 1686, wherein the one or more heat sources comprise
electrical heaters.

1692. The method of claim 1686, wherein the one or more heat sources comprise
surface burners.

1693. The method of claim 1686, wherein the one or more heat sources comprise
flameless distributed combustors.

1694. The method of claim 1686, wherein the one or more heat sources comprise natural
5 distributed combustors.

1695. The method of claim 1686, further comprising controlling a pressure and a
temperature within at least a majority of the selected section of the formation, wherein
the pressure is controlled as a function of temperature, or the temperature is controlled as
10 a function of pressure.

1696. The method of claim 1686, further comprising controlling the heat such that an
average heating rate of the selected section is less than about 1 °C per day during
pyrolysis.

15 1697. The method of claim 1686, wherein providing heat from the one or more heat
sources to at least the portion of formation comprises:

20 heating a selected volume (V) of the hydrocarbon containing formation from the
one or more heat sources, wherein the formation has an average heat capacity (C_v), and
wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of
the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr ,
wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

25 wherein Pwr is the heating energy/day, h is an average heating rate of the
formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10
°C/day.

1698. The method of claim 1686, wherein allowing the heat to transfer comprises
30 transferring heat substantially by conduction.

1699. The method of claim 1686, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

5 1700. The method of claim 1686, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

10 1701. The method of claim 1686, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

15 1702. The method of claim 1686, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

20 1703. The method of claim 1686, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

25 1704. The method of claim 1686, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

1705. The method of claim 1686, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

30 1706. The method of claim 1686, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

1707. The method of claim 1686, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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1708. The method of claim 1686, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

10 1709. The method of claim 1686, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

15 1710. The method of claim 1686, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

20 1711. The method of claim 1686, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

25 1712. The method of claim 1686, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1713. The method of claim 1686, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1714. The method of claim 1686, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

5 1715. The method of claim 1686, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

10 1716. The method of claim 1715, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

15 1717. The method of claim 1686, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1718. The method of claim 1686, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

20 1719. The method of claim 1686, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

25 1720. The method of claim 1686, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

30 1721. The method of claim 1686, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

1722. The method of claim 1686, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

5 1723. The method of claim 1686, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

10 1724. The method of claim 1686, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

15 1725. The method of claim 1686, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

20 1726. The method of claim 1686, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

25 1727. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation;
wherein the selected section has been selected for heating using a total organic matter weight percentage of at least a portion of the selected section, and wherein at least

the portion of the selected section comprises a total organic matter weight percentage, of at least about 5.0 %; and

producing a mixture from the formation.

5 1728. The method of claim 1727, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

10 1729. The method of claim 1727, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

15 1730. The method of claim 1727, wherein the one or more heat sources comprise electrical heaters.

1731. The method of claim 1727, wherein the one or more heat sources comprise surface burners.

20 1732. The method of claim 1727, wherein the one or more heat sources comprise flameless distributed combustors.

1733. The method of claim 1727, wherein the one or more heat sources comprise natural distributed combustors.

25 1734. The method of claim 1727, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1735. The method of claim 1727, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

5 1736. The method of claim 1727, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

10 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

15 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

20 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

1737. The method of claim 1727, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

25 1738. The method of claim 1727, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

1739. The method of claim 1727, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

30 1740. The method of claim 1727, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

1741. The method of claim 1727, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5 1742. The method of claim 1727, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

10 1743. The method of claim 1727, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

15 1744. The method of claim 1727, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

20 1745. The method of claim 1727, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

25 1746. The method of claim 1727, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

1747. The method of claim 1727, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

1748. The method of claim 1727, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5 1749. The method of claim 1727, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

10 1750. The method of claim 1727, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

15 1751. The method of claim 1727, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

20 1752. The method of claim 1727, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1753. The method of claim 1727, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

25 1754. The method of claim 1727, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 1755. The method of claim 1754, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

1756. The method of claim 1727, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5 1757. The method of claim 1727, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

10 1758. The method of claim 1727, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

15 1759. The method of claim 1727, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

20 1760. The method of claim 1727, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

1761. The method of claim 1727, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

25 1762. The method of claim 1727, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

30 1763. The method of claim 1727, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

1764. The method of claim 1727, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat
sources are located in the formation in a unit of heat sources, and wherein the unit of heat
sources comprises a triangular pattern.

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1765. The method of claim 1727, further comprising providing heat from three or more
heat sources to at least a portion of the formation, wherein three or more of the heat
sources are located in the formation in a unit of heat sources, wherein the unit of heat
sources comprises a triangular pattern, and wherein a plurality of the units are repeated
10 over an area of the formation to form a repetitive pattern of units.

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1766. A method of treating a hydrocarbon containing formation in situ, comprising:
15 providing heat from one or more heat sources to at least a portion of the
formation;

allowing the heat to transfer from the one or more heat sources to a selected
section of the formation;

wherein at least some hydrocarbons within the selected section have an initial
20 total organic matter weight percentage of at least about 5.0%; and

producing a mixture from the formation.

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1767. The method of claim 1766, wherein the one or more heat sources comprise at
least two heat sources, and wherein superposition of heat from at least the two heat
sources pyrolyzes at least some hydrocarbons within the selected section of the
25 formation.

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1768. The method of claim 1766, further comprising maintaining a temperature within
the selected section within a pyrolysis temperature range.

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1769. The method of claim 1766, wherein the one or more heat sources comprise
electrical heaters.

1770. The method of claim 1766, wherein the one or more heat sources comprise surface burners.

5 1771. The method of claim 1766, wherein the one or more heat sources comprise flameless distributed combustors.

10 1772. The method of claim 1766, wherein the one or more heat sources comprise natural distributed combustors.

15 1773. The method of claim 1766, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

20 1774. The method of claim 1766, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

25 1775. The method of claim 1766, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:
heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and
wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:
$$Pwr = h * V * C_v * \rho_B$$
wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

1776. The method of claim 1766, wherein allowing the heat to transfer comprises
transferring heat substantially by conduction.

5 1777. The method of claim 1766, wherein providing heat from the one or more heat
sources comprises heating the selected section such that a thermal conductivity of at least
a portion of the selected section is greater than about 0.5 W/(m °C).

10 1778. The method of claim 1766, wherein the produced mixture comprises condensable
hydrocarbons having an API gravity of at least about 25°.

15 1779. The method of claim 1766, wherein the produced mixture comprises condensable
hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the
condensable hydrocarbons are olefins.

20 1780. The method of claim 1766, wherein the produced mixture comprises non-
condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-
condensable hydrocarbons ranges from about 0.001 to about 0.15.

25 1781. The method of claim 1766, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is nitrogen.

1782. The method of claim 1766, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is oxygen.

30 1783. The method of claim 1766, wherein the produced mixture comprises condensable
hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic
basis, of the condensable hydrocarbons is sulfur.

1784. The method of claim 1766, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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1785. The method of claim 1766, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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1786. The method of claim 1766, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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1787. The method of claim 1766, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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1788. The method of claim 1766, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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1789. The method of claim 1766, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

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1790. The method of claim 1766, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1791. The method of claim 1766, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1792. The method of claim 1766, further comprising controlling a pressure within at 5 least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

1793. The method of claim 1766, further comprising controlling formation conditions to 10 produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

1794. The method of claim 1793, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

1795. The method of claim 1766, further comprising altering a pressure within the 15 formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1796. The method of claim 1766, further comprising controlling formation conditions 20 by recirculating a portion of hydrogen from the mixture into the formation.

1797. The method of claim 1766, further comprising:
25 providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

1798. The method of claim 1766, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a 30 portion of the produced hydrogen.

1799. The method of claim 1766, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

5 1800. The method of claim 1766, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

10 1801. The method of claim 1766, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

15 1802. The method of claim 1766, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 1803. The method of claim 1766, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 1804. The method of claim 1766, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30 1805. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation;
allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

wherein the selected section has been selected for heating using an atomic oxygen weight percentage of at least a portion of hydrocarbons in the selected section, and wherein at least a portion of the hydrocarbons in the selected section comprises an atomic oxygen weight percentage of less than about 15% when measured on a dry, ash free basis; and

producing a mixture from the formation.

1806. The method of claim 1805, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

1807. The method of claim 1805, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

1808. The method of claim 1805, wherein the one or more heat sources comprise electrical heaters.

1809. The method of claim 1805, wherein the one or more heat sources comprise surface burners.

1810. The method of claim 1805, wherein the one or more heat sources comprise flameless distributed combustors.

1811. The method of claim 1805, wherein the one or more heat sources comprise natural distributed combustors.

1812. The method of claim 1805, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1813. The method of claim 1805, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

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1814. The method of claim 1805, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

1815. The method of claim 1805, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

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1816. The method of claim 1805, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

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1817. The method of claim 1805, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

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1818. The method of claim 1805, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

1819. The method of claim 1805, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5

1820. The method of claim 1805, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

10 1821. The method of claim 1805, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

15 1822. The method of claim 1805, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

20 1823. The method of claim 1805, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

25 1824. The method of claim 1805, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

1825. The method of claim 1805, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

30

1826. The method of claim 1805, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5 1827. The method of claim 1805, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

10 1828. The method of claim 1805, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

15 1829. The method of claim 1805, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

20 1830. The method of claim 1805, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1831. The method of claim 1805, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

25 1832. The method of claim 1805, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 1833. The method of claim 1832, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

1834. The method of claim 1805, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5 1835. The method of claim 1805, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

1836. The method of claim 1805, further comprising:
10 providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

1837. The method of claim 1805, further comprising:
15 producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

1838. The method of claim 1805, wherein allowing the heat to transfer comprises
increasing a permeability of a majority of the selected section to greater than about 100
20 millidarcy.

1839. The method of claim 1805, wherein allowing the heat to transfer further
comprises substantially uniformly increasing a permeability of a majority of the selected
25 section.

1840. The method of claim 1805, further comprising controlling the heat to yield greater
than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer
Assay.

1841. The method of claim 1805, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

5 1842. The method of claim 1805, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

10 1843. The method of claim 1805, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

15 1844. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to a selected section of the formation;
allowing the heat to transfer from the one or more heat sources to the selected section of the formation to pyrolyze hydrocarbon within the selected section;
wherein at least some hydrocarbons within the selected section have an initial atomic oxygen weight percentage of less than about 15%; and
producing a mixture from the formation.

20 1845. The method of claim 1844, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

25 1846. The method of claim 1844, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range

1847. The method of claim 1844, wherein the one or more heat sources comprise electrical heaters.

5 1848. The method of claim 1844, wherein the one or more heat sources comprise surface burners.

10 1849. The method of claim 1844, wherein the one or more heat sources comprise flameless distributed combustors.

1850. The method of claim 1844, wherein the one or more heat sources comprise natural distributed combustors.

15 1851. The method of claim 1844, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

20 1852. The method of claim 1844, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

1853. The method of claim 1844, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

25 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

30 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

5 1854. The method of claim 1844, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

10 1855. The method of claim 1844, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

15 1856. The method of claim 1844, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

20 1857. The method of claim 1844, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

25 1858. The method of claim 1844, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

1859. The method of claim 1844, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

1860. The method of claim 1844, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

1861. The method of claim 1844, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5 1862. The method of claim 1844, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

10 1863. The method of claim 1844, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

15 1864. The method of claim 1844, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

20 1865. The method of claim 1844, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

25 1866. The method of claim 1844, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 1867. The method of claim 1844, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

1868. The method of claim 1844, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5 1869. The method of claim 1844, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1870. The method of claim 1844, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

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1871. The method of claim 1844, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

15

1872. The method of claim 1871, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

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1873. The method of claim 1844, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1874. The method of claim 1844, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

25

1875. The method of claim 1844, further comprising:

providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

30

1876. The method of claim 1844, further comprising:

producing hydrogen and condensable hydrocarbons from the formation; and

hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

1877. The method of claim 1844, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

1878. The method of claim 1844, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

10

1879. The method of claim 1844, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

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1880. The method of claim 1844, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

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1881. The method of claim 1844, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

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1882. The method of claim 1844, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30

1883. A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heat sources to at least a portion of the formation;

allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

5 wherein the selected section has been selected for heating using an atomic hydrogen to carbon ratio of at least a portion of hydrocarbons in the selected section, wherein at least a portion of the hydrocarbons in the selected section comprises an atomic hydrogen to carbon ratio greater than about 0.70, and wherein the atomic hydrogen to carbon ratio is less than about 1.65; and

10 producing a mixture from the formation.

1884. The method of claim 1883, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

1885. The method of claim 1883, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

20 1886. The method of claim 1883, wherein the one or more heat sources comprise electrical heaters.

1887. The method of claim 1883, wherein the one or more heat sources comprise surface burners.

25 1888. The method of claim 1883, wherein the one or more heat sources comprise flameless distributed combustors.

1889. The method of claim 1883, wherein the one or more heat sources comprise natural distributed combustors.

1890. The method of claim 1883, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

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1891. The method of claim 1883, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

10 1892. The method of claim 1883, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

15 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

20 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

1893. The method of claim 1883, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

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1894. The method of claim 1883, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

30 1895. The method of claim 1883, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

1896. The method of claim 1883, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

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1897. The method of claim 1883, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

10 1898. The method of claim 1883, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

15 1899. The method of claim 1883, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

20 1900. The method of claim 1883, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

25 1901. The method of claim 1883, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

1902. The method of claim 1883, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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1903. The method of claim 1883, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

5 1904. The method of claim 1883, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

10 1905. The method of claim 1883, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

15 1906. The method of claim 1883, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

20 1907. The method of claim 1883, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1908. The method of claim 1883, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

25 1909. The method of claim 1883, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

30 1910. The method of claim 1883, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

1911. The method of claim 1910, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

5 1912. The method of claim 1883, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

10 1913. The method of claim 1883, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

1914. The method of claim 1883, further comprising:

providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and

15 heating a portion of the section with heat from hydrogenation.

1915. The method of claim 1883, further comprising:

producing hydrogen and condensable hydrocarbons from the formation; and

20 hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

1916. The method of claim 1883, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

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1917. The method of claim 1883, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

30

1918. The method of claim 1883, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

1919. The method of claim 1883, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

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1920. The method of claim 1883, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

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1921. The method of claim 1883, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

15

1922. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to a selected section of the formation;

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allowing the heat to transfer from the one or more heat sources to the selected section of the formation to pyrolyze hydrocarbons within the selected section;
wherein at least some hydrocarbons within the selected section have an initial atomic hydrogen to carbon ratio greater than about 0.70;

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wherein the initial atomic hydrogen to carbon ratio is less than about 1.65; and
producing a mixture from the formation.

30

1923. The method of claim 1922, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

1924. The method of claim 1922, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

1925. The method of claim 1922, wherein the one or more heat sources comprise electrical heaters.

1926. The method of claim 1922, wherein the one or more heat sources comprise surface burners.

1927. The method of claim 1922, wherein the one or more heat sources comprise flameless distributed combustors.

1928. The method of claim 1922, wherein the one or more heat sources comprise natural distributed combustors.

1929. The method of claim 1922, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1930. The method of claim 1922, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

1931. The method of claim 1922, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:
heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than P_{wr} , wherein P_{wr} is calculated by the equation:

$$P_{wr} = h * V * C_v * \rho_B$$

wherein P_{wr} is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

1932. The method of claim 1922, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

10

1933. The method of claim 1922, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

15

1934. The method of claim 1922, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

20

1935. The method of claim 1922, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

25

1936. The method of claim 1922, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

1937. The method of claim 1922, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

1938. The method of claim 1922, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

5 1939. The method of claim 1922, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

10 1940. The method of claim 1922, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

15 1941. The method of claim 1922, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

20 1942. The method of claim 1922, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

25 1943. The method of claim 1922, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

1944. The method of claim 1922, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 1945. The method of claim 1922, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen,

wherin the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

5 1946. The method of claim 1922, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1947. The method of claim 1922, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

10 1948. The method of claim 1922, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

15 1949. The method of claim 1922, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

20 1950. The method of claim 1949, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

25 1951. The method of claim 1922, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1952. The method of claim 1922, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

30 1953. The method of claim 1922, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

1954. The method of claim 1922, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
5 hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

1955. The method of claim 1922, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.
10

1956. The method of claim 1922, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.
15

1957. The method of claim 1922, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.
20

1958. The method of claim 1922, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.
25

1959. The method of claim 1922, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.
30

1960. The method of claim 1922, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat

sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

1961. A method of treating a hydrocarbon containing formation in situ, comprising:

5 providing heat from one or more heat sources to at least a portion of the formation;

allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

10 wherein the selected section has been selected for heating using an atomic oxygen to carbon ratio of at least a portion of hydrocarbons in the selected section, wherein at least a portion of the hydrocarbons in the selected section comprises an atomic oxygen to carbon ratio greater than about 0.025, and wherein the atomic oxygen to carbon ratio of at least a portion of the hydrocarbons in the selected section is less than about 0.15 and producing a mixture from the formation.

15 1962. The method of claim 1961, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

20 1963. The method of claim 1961, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

25 1964. The method of claim 1961, wherein the one or more heat sources comprise electrical heaters.

1965. The method of claim 1961, wherein the one or more heat sources comprise surface burners.

30 1966. The method of claim 1961, wherein the one or more heat sources comprise flameless distributed combustors.

1967. The method of claim 1961, wherein the one or more heat sources comprise natural distributed combustors.

5 1968. The method of claim 1961, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

10 1969. The method of claim 1961, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

15 1970. The method of claim 1961, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

20 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

25 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

1971. The method of claim 1961, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

1972. The method of claim 1961, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

5 1973. The method of claim 1961, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

10 1974. The method of claim 1961, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins

15 1975. The method of claim 1961, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

20 1976. The method of claim 1961, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

25 1977. The method of claim 1961, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

30 1978. The method of claim 1961, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

1979. The method of claim 1961, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

1980. The method of claim 1961, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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1981. The method of claim 1961, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

10 1982. The method of claim 1961, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

15 1983. The method of claim 1961, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

20 1984. The method of claim 1961, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

25 1985. The method of claim 1961, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1986. The method of claim 1961, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1987. The method of claim 1961, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

5 1988. The method of claim 1961, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

10 1989. The method of claim 1988, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

15 1990. The method of claim 1961, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1991. The method of claim 1961, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

20 1992. The method of claim 1961, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

25 1993. The method of claim 1961, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

30 1994. The method of claim 1961, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

1995. The method of claim 1961, wherein allowing the heat to transfer further comprises substantially uniformly increasing a permeability of a majority of the selected section.

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1996. The method of claim 1961, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

10 1997. The method of claim 1961, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

15 1998. The method of claim 1961, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

20 1999. The method of claim 1961, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

25 2000. A method of treating a hydrocarbon containing formation in situ, comprising providing heat from one or more heat sources to a selected section of the formation;

allowing the heat to transfer from the one or more heat sources to the selected section of the formation to pyrolyze hydrocarbons within the selected section;

30 wherein at least some hydrocarbons within the selected section have an initial atomic oxygen to carbon ratio greater than about 0.025;

wherein the initial atomic oxygen to carbon ratio is less than about 0.15; and producing a mixture from the formation.

2001. The method of claim 2000, wherein the one or more heat sources comprise at 5 least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

2002. The method of claim 2000, further comprising maintaining a temperature within 10 the selected section within a pyrolysis temperature range.

2003. The method of claim 2000, wherein the one or more heat sources comprise electrical heaters.

15 2004. The method of claim 2000, wherein the one or more heat sources comprise surface burners.

2005. The method of claim 2000, wherein the one or more heat sources comprise flameless distributed combustors.

20 2006. The method of claim 2000, wherein the one or more heat sources comprise natural distributed combustors.

25 2007. The method of claim 2000, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

30 2008. The method of claim 2000, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

2009. The method of claim 2000, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

5 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

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$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

15 2010. The method of claim 2000, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

20 2011. The method of claim 2000, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

2012. The method of claim 2000, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

25 2013. The method of claim 2000, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

30 2014. The method of claim 2000, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

2015. The method of claim 2000, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

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2016. The method of claim 2000, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

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2017. The method of claim 2000, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

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2018. The method of claim 2000, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5% by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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2019. The method of claim 2000, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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2020. The method of claim 2000, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2021. The method of claim 2000, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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2022. The method of claim 2000, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5 2023. The method of claim 2000, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10% by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

10 2024. The method of claim 2000, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

15 2025. The method of claim 2000, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

20 2026. The method of claim 2000, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

25 2027. The method of claim 2000, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 2028. The method of claim 2027, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

2029. The method of claim 2000, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2030. The method of claim 2000, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

2031. The method of claim 2000, further comprising:
5 providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

2032. The method of claim 2000, further comprising:
10 producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

2033. The method of claim 2000, wherein allowing the heat to transfer comprises
15 increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

2034. The method of claim 2000, wherein allowing the heat to transfer further comprises substantially uniformly increasing a permeability of a majority of the selected section.
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2035. The method of claim 2000, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.
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2036. The method of claim 2000, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

2037. The method of claim 2000, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat
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sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

2038. The method of claim 2000, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

10. 2039. A method of treating a hydrocarbon containing formation in situ, comprising:
5 providing heat from one or more heat sources to at least a portion of the formation;

15 allowing the heat to transfer from the one or more heat sources to a selected section of the formation;

20 wherein the selected section has been selected for heating using a moisture content in the selected section, and wherein at least a portion of the selected section comprises a moisture content of less than about 15%; and

25 producing a mixture from the formation.

2040. The method of claim 2039, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

25 2041. The method of claim 2039, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

2042. The method of claim 2039, wherein the one or more heat sources comprise electrical heaters.

2043. The method of claim 2039, wherein the one or more heat sources comprise surface burners.

2044. The method of claim 2039, wherein the one or more heat sources comprise 5 flameless distributed combustors.

2045. The method of claim 2039, wherein the one or more heat sources comprise natural distributed combustors.

10 2046. The method of claim 2039, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

15 2047. The method of claim 2039, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

20 2048. The method of claim 2039, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

25 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 30 °C/day.

2049. The method of claim 2039, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

2050. The method of claim 2039, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

2051. The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

10 2052. The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

15 2053. The method of claim 2039, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

20 2054. The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

25 2055. The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

30 2056. The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

2057. The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

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2058. The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

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2059. The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

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2060. The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

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2061. The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

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2062. The method of claim 2039, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

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2063. The method of claim 2039, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

2064. The method of claim 2039, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

2065. The method of claim 2039, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

2066. The method of claim 2039, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

2067. The method of claim 2066, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

2068. The method of claim 2039, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2069. The method of claim 2039, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

2070. The method of claim 2039, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

2071. The method of claim 2039, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

2072. The method of claim 2039, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

5 2073. The method of claim 2039, wherein allowing the heat to transfer further comprises substantially uniformly increasing a permeability of a majority of the selected section.

10 2074. The method of claim 2039, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

15 2075. The method of claim 2039, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 2076. The method of claim 2039, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 2077. The method of claim 2039, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30 2078. A method of treating a hydrocarbon containing formation in situ, comprising: providing heat from one or more heat sources to a selected section of the formation;

allowing the heat to transfer from the one or more heat sources to the selected section of the formation;

wherein at least a portion of the selected section has an initial moisture content of less than about 15%; and

5 producing a mixture from the formation.

2079. The method of claim 2078, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the
10 formation.

2080. The method of claim 2078, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

15 2081. The method of claim 2078, wherein the one or more heat sources comprise electrical heaters.

2082. The method of claim 2078, wherein the one or more heat sources comprise surface burners.

20 2083. The method of claim 2078, wherein the one or more heat sources comprise flameless distributed combustors.

25 2084. The method of claim 2078, wherein the one or more heat sources comprise natural distributed combustors.

30 2085. The method of claim 2078, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2086. The method of claim 2078, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

5 2087. The method of claim 2078, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

10 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

15 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

2088. The method of claim 2078, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

20 2089. The method of claim 2078, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

25 2090. The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

2091. The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

2092. The method of claim 2078, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5 2093. The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

10 2094. The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

15 2095. The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

20 2096. The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

25 2097. The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

2098. The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2099. The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5 2100. The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

10 2101. The method of claim 2078, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

15 2102. The method of claim 2078, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

20 2103. The method of claim 2078, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

2104. The method of claim 2078, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

25 2105. The method of claim 2078, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 2106. The method of claim 2105, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

2107. The method of claim 2078, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5 2108. The method of claim 2078, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

10 2109. The method of claim 2078, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

15 2110. The method of claim 2078, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

20 2111. The method of claim 2078, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

25 2112. The method of claim 2078, wherein allowing the heat to transfer further comprises substantially uniformly increasing a permeability of a majority of the selected section.

2113. The method of claim 2078, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

2114. The method of claim 2078, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

5 2115. The method of claim 2078, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

10 2116. The method of claim 2078, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

15 2117. A method of treating a hydrocarbon containing formation in situ, comprising:
 providing heat from one or more heat sources to at least a portion of the formation;
 allowing the heat to transfer from the one or more heat sources to a selected section of the formation;
 wherein the selected section is heated in a reducing environment during at least a portion of the time that the selected section is being heated; and
 producing a mixture from the formation.

20 2118. The method of claim 2117, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

25 2119. The method of claim 2117, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

2120. The method of claim 2117, wherein the one or more heat sources comprise electrical heaters.

5 2121. The method of claim 2117, wherein the one or more heat sources comprise surface burners.

2122. The method of claim 2117, wherein the one or more heat sources comprise flameless distributed combustors.

10 2123. The method of claim 2117, wherein the one or more heat sources comprise natural distributed combustors.

15 2124. The method of claim 2117, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

20 2125. The method of claim 2117, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

2126. The method of claim 2117, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

25 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

30 wherein heating energy/day provided to the volume is equal to or less than P_{wr} , wherein P_{wr} is calculated by the equation:

$$P_{wr} = h * V * C_v * \rho_B$$

wherein P_{wr} is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

5 2127. The method of claim 2117, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

10 2128. The method of claim 2117, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

2129. The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

15 2130. The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

20 2131. The method of claim 2117, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

25 2132. The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

2133. The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

2134. The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5 2135. The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

10 2136. The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

15 2137. The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

20 2138. The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

25 2139. The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

30 2140. The method of claim 2117, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

2141. The method of claim 2117, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

2142. The method of claim 2117, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

2143. The method of claim 2117, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

2144. The method of claim 2117, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

2145. The method of claim 2144, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

2146. The method of claim 2117, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2147. The method of claim 2117, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

2148. The method of claim 2117, further comprising:
providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and
heating a portion of the section with heat from hydrogenation.

2149. The method of claim 2117, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and

hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

2150. The method of claim 2117, wherein allowing the heat to transfer comprises
5 increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

2151. The method of claim 2117, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

10 2152. The method of claim 2117, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

15 2153. The method of claim 2117, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 2154. The method of claim 2117, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 2155. The method of claim 2117, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30 2156. A method of treating a hydrocarbon containing formation in situ, comprising: heating a first section of the formation to produce a mixture from the formation;

heating a second section of the formation; and
recirculating a portion of the produced mixture from the first section into the
second section of the formation to provide a reducing environment within the second
section of the formation.

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2157. The method of claim 2156, further comprising maintaining a temperature within
the first section or the second section within a pyrolysis temperature range.

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2158. The method of claim 2156, wherein heating the first or the second section
comprises heating with an electrical heater.

2159. The method of claim 2156, wherein heating the first or the second section
comprises heating with a surface burner.

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2160. The method of claim 2156, wherein heating the first or the second section
comprises heating with a flameless distributed combustor.

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2161. The method of claim 2156, wherein heating the first or the second section
comprises heating with a natural distributed combustor.

25

2162. The method of claim 2156, further comprising controlling a pressure and a
temperature within at least a majority of the first or second section of the formation,
wherein the pressure is controlled as a function of temperature, or the temperature is
controlled as a function of pressure.

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2163. The method of claim 2156, further comprising controlling the heat such that an
average heating rate of the first or the second section is less than about 1 °C per day
during pyrolysis.

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2164. The method of claim 2156, wherein heating the first or the second section
comprises:

heating a selected volume (V) of the hydrocarbon containing formation from one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

5 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10
10 $^{\circ}\text{C}/\text{day}$.

2165. The method of claim 2156, wherein heating the first or the second section comprises transferring heat substantially by conduction.

15 2166. The method of claim 2156, wherein heating the first or the second section comprises heating the first or the second section such that a thermal conductivity of at least a portion of the first or the second section is greater than about 0.5 $\text{W}/(\text{m } ^{\circ}\text{C})$.

20 2167. The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25 $^{\circ}$.

2168. The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

25 2169. The method of claim 2156, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

2170. The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

5 2171. The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

10 2172. The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

15 2173. The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

20 2174. The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

25 2175. The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2176. The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

2177. The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5 2178. The method of claim 2156, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

10 2179. The method of claim 2156, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

15 2180. The method of claim 2156, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

20 2181. The method of claim 2156, further comprising controlling a pressure within at least a majority of the first or second section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

25 2182. The method of claim 2156, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

30 2183. The method of claim 2182, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

2184. The method of claim 2156, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2185. The method of claim 2156, further comprising:
providing hydrogen (H₂) to the first or second section to hydrogenate hydrocarbons within the first or second section; and
heating a portion of the first or second section with heat from hydrogenation.

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2186. The method of claim 2156, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

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2187. The method of claim 2156, wherein heating the first or the second section comprises increasing a permeability of a majority of the first or the second section to greater than about 100 millidarcy.

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2188. The method of claim 2156, wherein heating the first or the second section comprises substantially uniformly increasing a permeability of a majority of the first or the second section.

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2189. The method of claim 2156, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

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2190. The method of claim 2156, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

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2191. The method of claim 2156, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

2192. The method of claim 2156, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

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2193. A method of treating a hydrocarbon containing formation in situ, comprising:
providing heat from one or more heat sources to at least a portion of the formation; and

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allowing the heat to transfer from the one or more heat sources to a selected section of the formation such that a permeability of at least a portion of the selected section increases to greater than about 100 millidarcy.

15
2194. The method of claim 2193, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

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2195. The method of claim 2193, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

2196. The method of claim 2193, wherein the one or more heat sources comprise electrical heaters.

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2197. The method of claim 2193, wherein the one or more heat sources comprise surface burners.

2198. The method of claim 2193, wherein the one or more heat sources comprise flameless distributed combustors.

2199. The method of claim 2193, wherein the one or more heat sources comprise natural distributed combustors.

2200. The method of claim 2193, further comprising controlling a pressure and a 5 temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2201. The method of claim 2193, further comprising controlling the heat such that an 10 average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

2202. The method of claim 2193, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

15 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

20 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

25 2203. The method of claim 2193, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

30 2204. The method of claim 2193, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

2205. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

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2206. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

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2207. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

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2208. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

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2209. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

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2210. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

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2211. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

2212. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

2213. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2214. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

2215. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

2216. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

2217. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

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2218. The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

10 2219. The method of claim 2193, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

15 2220. The method of claim 2193, further comprising controlling formation conditions to produce a mixture from the formation, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

20 2221. The method of claim 2220, further comprising producing a mixture from the formation, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

25 2222. The method of claim 2193, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2223. The method of claim 2193, further comprising producing a mixture from the formation and controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

30 2224. The method of claim 2193, further comprising:

providing hydrogen (H_2) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

5 2225. The method of claim 2193, further comprising:

producing hydrogen and condensable hydrocarbons from the formation; and

hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

10 2226. The method of claim 2193, further comprising increasing a permeability of a majority of the selected section to greater than about 5 Darcy.

15 2227. The method of claim 2193, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

20 2228. The method of claim 2193, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

2229. The method of claim 2193, further comprising producing a mixture in a production well, wherein at least about 7 heat sources are disposed in the formation for each production well.

25 2230. The method of claim 2193, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

30 2231. The method of claim 2193, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat

sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

2232. A method of treating a hydrocarbon containing formation in situ, comprising:

5 providing heat from one or more heat sources to at least a portion of the formation; and

allowing the heat to transfer from the one or more heat sources to a selected section of the formation such that a permeability of a majority of at least a portion of the selected section increases substantially uniformly.

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2233. The method of claim 2232, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

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2234. The method of claim 2232, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

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2235. The method of claim 2232, wherein the one or more heat sources comprise electrical heaters.

2236. The method of claim 2232, wherein the one or more heat sources comprise surface burners.

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2237. The method of claim 2232, wherein the one or more heat sources comprise flameless distributed combustors.

2238. The method of claim 2232, wherein the one or more heat sources comprise natural distributed combustors.

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2239. The method of claim 2232, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

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2240. The method of claim 2232, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

10 2241. The method of claim 2232, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

15 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

20 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

2242. The method of claim 2232, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

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2243. The method of claim 2232, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

2244. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5 2245. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

10 2246. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

15 2247. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

20 2248. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1% by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

25 2249. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

30 2250. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, wherein

about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

5 2251. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

10 2252. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

15 2253. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

20 2254. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

25 2255. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen, wherein the hydrogen is greater than about 10 % by volume of the non-condensable component, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component.

2256. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5 2257. The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

10 2258. The method of claim 2232, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

15 2259. The method of claim 2232, further comprising controlling formation conditions to produce a mixture from the formation, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

20 2260. The method of claim 2232, further comprising producing a mixture from the formation, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

2261. The method of claim 2232, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

25 2262. The method of claim 2232, further comprising producing a mixture from the formation and controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

2263. The method of claim 2232, further comprising:
30 providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

2264. The method of claim 2232, further comprising producing hydrogen and condensable hydrocarbons from the formation; and hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

2265. The method of claim 2232, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

2266. The method of claim 2232, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

2267. The method of claim 2232, further comprising producing a mixture in a production well, wherein at least about 7 heat sources are disposed in the formation for each production well.

2268. The method of claim 2232, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

2269. The method of claim 2232, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

2270. A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heat sources to at least a portion of the formation; and

allowing the heat to transfer from the one or more heat sources to a selected section of the formation such that a porosity of a majority of at least a portion of the selected section increases substantially uniformly.

2271. The method of claim 2270, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

2272. The method of claim 2270, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

2273. The method of claim 2270, wherein the one or more heat sources comprise electrical heaters.

2274. The method of claim 2270, wherein the one or more heat sources comprise surface burners.

2275. The method of claim 2270, wherein the one or more heat sources comprise flameless distributed combustors.

2276. The method of claim 2270, wherein the one or more heat sources comprise natural distributed combustors.

2277. The method of claim 2270, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2278. The method of claim 2270, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

5 2279. The method of claim 2270, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

10 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

15 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

20 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

2280. The method of claim 2270, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

25 2281. The method of claim 2270, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

2282. The method of claim 2270, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

30 2283. The method of claim 2270, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and

wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

2284. The method of claim 2270, further comprising producing a mixture from the
5 formation, wherein the produced mixture comprises non-condensable hydrocarbons, and
wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges
from about 0.001 to about 0.15.

2285. The method of claim 2270, further comprising producing a mixture from the
10 formation, wherein the produced mixture comprises condensable hydrocarbons, and
wherein less than about 1 % by weight, when calculated on an atomic basis, of the
condensable hydrocarbons is nitrogen.

2286. The method of claim 2270, further comprising producing a mixture from the
15 formation, wherein the produced mixture comprises condensable hydrocarbons, and
wherein less than about 1 % by weight, when calculated on an atomic basis, of the
condensable hydrocarbons is oxygen.

2287. The method of claim 2270, further comprising producing a mixture from the
20 formation, wherein the produced mixture comprises condensable hydrocarbons, and
wherein less than about 1 % by weight, when calculated on an atomic basis, of the
condensable hydrocarbons is sulfur.

2288. The method of claim 2270, further comprising producing a mixture from the
25 formation, wherein the produced mixture comprises condensable hydrocarbons, wherein
about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise
oxygen containing compounds, and wherein the oxygen containing compounds comprise
phenols.

2289. The method of claim 2270, further comprising producing a mixture from the
30 formation, wherein the produced mixture comprises condensable hydrocarbons, and

wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

2290. The method of claim 2270, further comprising producing a mixture from the
5 formation, wherein the produced mixture comprises condensable hydrocarbons, and
wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-
ring aromatics with more than two rings.

2291. The method of claim 2270, further comprising producing a mixture from the
10 formation, wherein the produced mixture comprises condensable hydrocarbons, and
wherein less than about 0.3 % by weight of the condensable hydrocarbons are
asphaltenes.

2292. The method of claim 2270, further comprising producing a mixture from the
15 formation, wherein the produced mixture comprises condensable hydrocarbons, and
wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons
are cycloalkanes.

2293. The method of claim 2270, further comprising producing a mixture from the
20 formation, wherein the produced mixture comprises a non-condensable component,
wherein the non-condensable component comprises hydrogen, wherein the hydrogen is
greater than about 10 % by volume of the non-condensable component, and wherein the
hydrogen is less than about 80 % by volume of the non-condensable component.

2294. The method of claim 2270, further comprising producing a mixture from the
25 formation, wherein the produced mixture comprises ammonia, and wherein greater than
about 0.05 % by weight of the produced mixture is ammonia.

2295. The method of claim 2270, further comprising producing a mixture from the
30 formation, wherein the produced mixture comprises ammonia, and wherein the ammonia
is used to produce fertilizer.

2296. The method of claim 2270, further comprising controlling a pressure within at least a majority of the selected section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

5

2297. The method of claim 2270, further comprising controlling formation conditions to produce a mixture from the formation, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

10

2298. The method of claim 2270, further comprising producing a mixture from the formation, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

15

2299. The method of claim 2270, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

20

2300. The method of claim 2270, further comprising producing a mixture from the formation and controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

25

2301. The method of claim 2270, further comprising:

providing hydrogen (H₂) to the heated section to hydrogenate hydrocarbons within the section; and

heating a portion of the section with heat from hydrogenation.

2302. The method of claim 2270, further comprising:

producing hydrogen and condensable hydrocarbons from the formation; and

hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

30

2303. The method of claim 2270, wherein allowing the heat to transfer comprises increasing a permeability of a majority of the selected section to greater than about 100 millidarcy.

5 2304. The method of claim 2270, wherein allowing the heat to transfer comprises substantially uniformly increasing a permeability of a majority of the selected section.

10 2305. The method of claim 2270, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

15 2306. The method of claim 2270, further comprising producing a mixture in a production well, and wherein at least about 7 heat sources are disposed in the formation for each production well.

20 2307. The method of claim 2270, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, and wherein the unit of heat sources comprises a triangular pattern.

25 2308. The method of claim 2270, further comprising providing heat from three or more heat sources to at least a portion of the formation, wherein three or more of the heat sources are located in the formation in a unit of heat sources, wherein the unit of heat sources comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

30 2309. A method of treating a hydrocarbon containing formation in situ, comprising:
 providing heat from one or more heat sources to at least a portion of the formation;
 allowing the heat to transfer from the one or more heat sources to a selected section of the formation; and

controlling the heat to yield at least about 15 % by weight of a total organic carbon content of at least some of the hydrocarbon containing formation into condensable hydrocarbons.

5 2310. The method of claim 2309, wherein the one or more heat sources comprise at least two heat sources, and wherein superposition of heat from at least the two heat sources pyrolyzes at least some hydrocarbons within the selected section of the formation.

10 2311. The method of claim 2309, further comprising maintaining a temperature within the selected section within a pyrolysis temperature range.

15 2312. The method of claim 2309, wherein the one or more heat sources comprise electrical heaters.

20 2313. The method of claim 2309, wherein the one or more heat sources comprise surface burners.

2314. The method of claim 2309, wherein the one or more heat sources comprise flameless distributed combustors.

25 2315. The method of claim 2309, wherein the one or more heat sources comprise natural distributed combustors.

2316. The method of claim 2309, further comprising controlling a pressure and a temperature within at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2317. The method of claim 2309, further comprising controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day during pyrolysis.

5 2318. The method of claim 2309, wherein providing heat from the one or more heat sources to at least the portion of formation comprises:

10 heating a selected volume (V) of the hydrocarbon containing formation from the one or more heat sources, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

15 wherein heating energy/day provided to the volume is equal to or less than Pwr , wherein Pwr is calculated by the equation:

$$Pwr = h * V * C_v * \rho_B$$

20 wherein Pwr is the heating energy/day, h is an average heating rate of the formation, ρ_B is formation bulk density, and wherein the heating rate is less than about 10 °C/day.

2319. The method of claim 2309, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

25 2320. The method of claim 2309, wherein providing heat from the one or more heat sources comprises heating the selected section such that a thermal conductivity of at least a portion of the selected section is greater than about 0.5 W/(m °C).

2321. The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

30 2322. The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and

wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

2323. The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

2324. The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

2325. The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

2326. The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

2327. The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

2328. The method of claim 2309, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and